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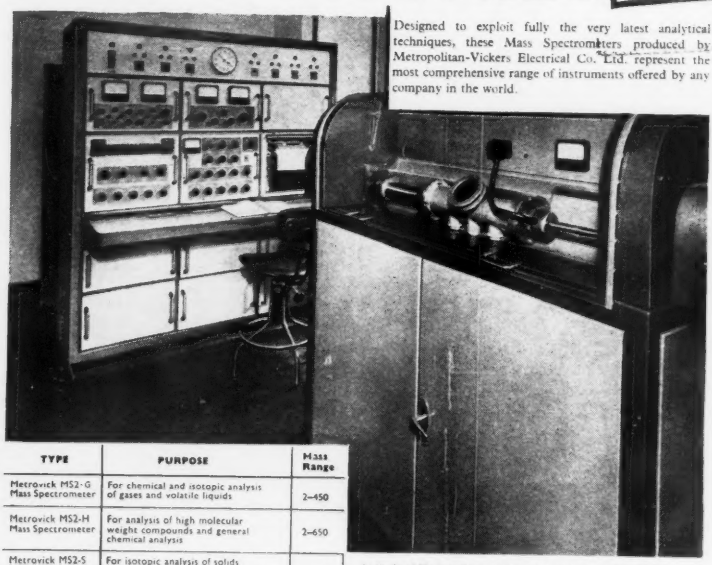

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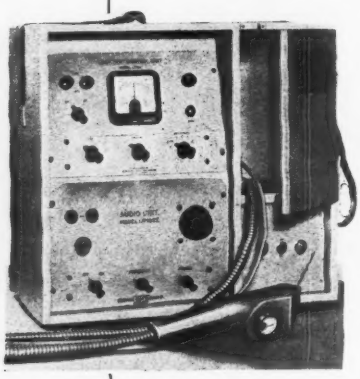

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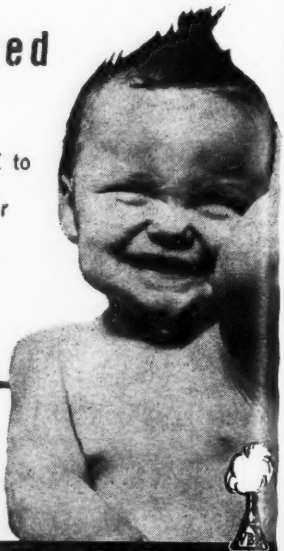

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CONFERENCES: BIG OR SMALL?

MORE science means more information, in the form of books, journals and conferences. No scientist needs to be reminded of this. It was estimated recently that to keep up with all the current work a physiologist would have to read nearly four hundred papers a day; Sir George Thomson has even gone so far as to suggest that it is the impossibility of absorbing the necessary information that will ultimately halt scientific progress. Communication is therefore a subject that we cannot afford to neglect. The purposes of books and journals are, or should be, obvious; but the functions of conferences are more complicated.

Scientific conferences grew as an answer to the problem of assimilating in a reasonable time the vast quantities of information scattered throughout the journals. They do provide an answer—the meeting together of workers in similar fields and the collection of their ideas are the obvious advantages. But is it the best answer? The basis of a conference is the presentation of papers; but why bother to read them? The distribution of all the papers to all the members would serve the same purpose. It would even have advantages: it is much easier to read a foreign language than to follow it by ear, and it is difficult to grasp a complicated argument at a single hearing. In fact, something of the sort often happens when preprints are issued or when the proceedings are published in book form afterwards.

The preprint was introduced to save time. If all his audience are armed with his complete paper, there is no need for a speaker to give more than a summary. This frees time for discussion or, more frequently, more papers. But the possibility of discussion is the great advantage of conferences. Questions can be asked and suggestions made in print, but it is a very slow business and what takes months in the journals may take only minutes in the conference room. Conferences have other advantages, of course. Meeting other workers in one's own field is an obvious one. But this is really an extension of the main advantage: one meets in order to discuss.

Conferences are getting bigger. The Fourth International Congress of Biochemistry held in Vienna last September was attended by nearly five thousand scientists and the published proceedings run to fifteen volumes. Two thousand one hundred papers were submitted at the Second Geneva Conference on the Peaceful Uses of Atomic Energy, and there are thirty-three volumes of proceedings. These two examples are exceptions, but they do represent a real trend, at least in international conferences. The question is whether this trend is a good thing. Are bigger conferences necessarily better? In particular, are they better with regard to the advantages that conferences have over other methods of communication? The answer is, surely, no. It has already been pointed out that the great asset of conferences is discussion, and the value of a discussion is usually inversely proportional to the size of the group. There is such a press of papers that it is difficult to find time to read them, let alone discuss them. Furthermore, most big conferences have to split up into sections which meet at the same time, and so it is impossible for an active member of a section to get any idea of the conference as a whole. 'Interdisciplinary cross-fertilization', as it is unhappily called, does not take place.

Fortunately, many people are aware of these points; in particular, some of the research foundations, such as the Ciba Foundation in Britain which recently celebrated its tenth anniversary, and the Josiah Macy Jr. Foundation in the United States, deserve mention. Both these organizations sponsor symposia. Membership of a symposium is restricted to a small number of experts, so that profitable discussions are possible. Afterwards, the complete proceedings are published. It is a pity that there are so few institutions of this type interested in the physical sciences; most of them are biological, with a bias towards medicine.

The Gordon Research Conferences, many of which are held every year in the United States, illustrate yet another approach. They cover both the physical and biological sciences, and the membership of any one conference is restricted to a hundred. They are "intended as a means of disseminating information which otherwise would not be realized through the normal channels of publication and scientific meetings". They differ from other conferences in that nothing is published, and no information may be disclosed without the speaker's consent. At first this may seem odd in connexion with a conference "intended as a means of disseminating scientific information", but it enables those present to speculate freely without feeling that hundreds of critical readers will later censure them for making suggestions not backed up by adequate evidence. Speculation is a vital part of science, so it is desirable that there should be some means whereby people can do so together, as well as alone. A series of meetings of the Gordon type has recently been established in Britain. The first Miller conference*, on radiation chemistry, was held at Portmeirion in North Wales during April 20–24 and was a success. The conferences have been named after the late Dr. N. Miller, of the University of Edinburgh, who did much to help establish them.

Big conferences are obviously here to stay. Many important aspects of them have not been discussed here, such as their significance as social events which promote international understanding, though it is to be hoped that the tendency to compete for national prestige, evident at some recent conferences, will not have the opposite effect. Nevertheless, the small informal gathering, where ideas are exchanged as freely as facts, should not be neglected.

* Further information about the Miller conferences can be obtained from the chairman of the next meeting, which is to be held in 1961—Prof. F. S. Dainton, School of Chemistry, The University, Leeds 2.

HISTORY OF COSMOLOGY

Le Système du Monde

Histoire des Doctrines Cosmologiques de Platon à Copernic, Tome 10. Par Prof. Pierre Duhem. Pp. 528. (Paris : Hermann, 1959.) n.p.

THE great work of the late French historian of science, Pierre Duhem, on the history of cosmology from Plato to Copernicus, is now completed by the publication of Volumes 9 and 10. It will be remembered that only the first five volumes were published during the author's life in the years 1914–17. At the time there was no possibility of publishing the extant material for the remaining volumes, and it seemed that the historians of science would have to become resigned to the valuable work remaining a torso for ever. However, after the Second World War circumstances were ameliorated and so the rather rare situation could arise of the missing volumes appearing some forty years after the beginning of publication. On a previous occasion comment has been made upon the unavoidable drawback of the work becoming somewhat antiquated in the meantime. This, however, is only a slight disadvantage in comparison to the immense value to be attributed to Duhem's pioneering work, which forms the beginning of the modern interest in medieval natural science.

Of the new volumes, Volume 9 brings to completion the subject-matter of Volumes 7 and 8, mainly consisting of the Parisian physics of the fourteenth century. First, the theory of the tides is dealt with from William of Auvergne to Pierre d'Ailly ; then follows the equilibrium of the Earth and the oceans, with an introduction to the idea of their centre of gravity of Greek and Arab commentators of Aristotle ; the origins of geology, including the theory of the small movements of the Earth. Hereafter the important question of the rotation of the Earth is tackled, the discussion of which was inaugurated by Duhem in 1909 in his epoch-making article on Oresme as a precursor of Copernicus, in the *Revue Générale des Sciences*. This article is substantially reproduced here and is supplemented by a discussion of the views of that other great figure of medieval physics, Jean Buridan. The author repeats his former conclusion that the daily rotation of the Earth was duly discussed in the Parisian school of the fourteenth century and that in particular Oresme deserves credit for his anticipation of the ideas of Copernicus on the Earth's daily rotation. In the final chapter of Volume 9 the problems of the plurality of worlds in connexion with the possibility of the vacuum and with the variability of gravity with the distance to the centre of the world are discussed.

In Volume 10 it becomes quite clear that it is not offered to us as a complete work, but only as a compilation of fragments in greater or lesser degree of perfection. The title of the whole of Volume 10 was not chosen by Duhem himself but was added by the editors, who hoped to sum up by it the principal contents of the volume. It announces a treatment of fifteenth-century cosmology and of the schools and universities in which it was developed. The decline of the University of Paris in the first half of the fifteenth century is dealt with rather elaborately, but the treatment of the subsequent developments leaves something to be desired. The German universities of that century receive full attention, but the English and Italian ones remain somewhat in the background ; although Paul of Venice (Paolo Nicoletti) has an extensive chapter devoted to him. This is also the case of Nicolaus of Cusa, the German cardinal, whose ideas are expounded at length. Finally, there are chapters on the Viennese astronomers Peurbach and Regiomontanus and on the fourteenth-century humanists Petrarca and L. Bruni, which, however, are far from dealing exhaustively with the relation of humanism to medieval philosophy.

The treatment is everywhere extremely clear and interesting ; one regrets that the work was not completed by its author. E. J. DIJKSTERHUIS

RUSSIAN VIEW OF SPACE FLIGHT

Sputniks and After

By Karl Gilzin. Translated from the Russian by Pauline Rose. Pp. 285+25 photographs. (London : Macdonald and Co. (Publishers), Ltd., 1959.) 21*s.* net.

KARL GILZIN, a lecturer at the Moscow Aviation Institute, gives here a popular account of the past, present and probable future of space flight. Brooding over the whole story is the spirit of Tsiolkovski, the 'father of astronautics', who foresaw in remarkable detail the techniques likely to prove most efficacious in space flight. Since British and American authors have scarcely done justice to this Russian pioneer, the eulogy in the present book will do no harm. It also serves to remind us how the Russians have created, around the name of Tsiolkovski as patron saint, a mystique of space flight which is unparalleled in the Western world : it is no accident that experiments with animals, a necessary prelude to manned space travel, have figured so largely in the Soviet rocket and satellite programmes, or that *Sputnik* 1 was launched within a month of the centenary of Tsiolkovski's birth.

The subject-matter of the book can be divided into three sections, past, present and future. The first section expounds the principles of space flight and traces the development of rockets and other power units in fair detail, though with a pro-Russian bias : Tsiolkovski figures in the history of the gas-turbine engine, but not Whittle. The second section, covering present developments, though it includes a good chapter on the atmosphere, is disappointing in detail : there is no new information on the Sputniks, and the meagre report of the results obtained from them (which appears to date from mid-1958) is, a little surprisingly, based largely on British radio observations reported in *Nature*. The last section is an excellent preview of space flight, which ends with an imaginary but realistic excursion to the Moon by a party of school-children.

The material is presented in an easy, expert manner and the book is well illustrated and technically reliable. There are a number of lapses and inconsistencies, however : for example, the rocket of *Sputnik* 1 is on p. 117 said to have completed its 900th circuit of the Earth on December 2, 1957, when it really came down on the previous day, as is implied on p. 131 ; on p. 139 Jodrell Bank is described as an Irish radio observatory, a peccadillo startling to parochial ears ; and the last paragraph on p. 102 does not follow from the one before.

The translation is competent, but too overloaded with abstract nouns to be called graceful, and the phraseology sometimes conflicts with established usage : 'thrust' sometimes masquerades as 'traction', and 'solid fuel' as 'dry fuel'. D. G. KING-HELE

VAPOUR–LIQUID EQUILIBRIUM TREATISE

Vapour–Liquid Equilibrium

By Eduard Hála, Jiří Pick, Vojtěch Fried and Otakar Vilím. Translated by G. Standart. (Czechoslovak Academy of Sciences. Monographs and Source Material: Chemical Section.) Pp. xviii+402. (London and New York: Pergamon Press, 1958.) 90*s*. net.

THE authors have made an effort to produce a comprehensive treatise on all aspects of vapour–liquid equilibrium, and certainly this is the most complete work yet to appear on the subject. It is divided into three parts, covering respectively the thermodynamic basis for correlation of data, experimental techniques of measurement, and an up-to-date survey of the relevant literature. The theoretical basis of the subject is developed in four chapters, starting with general thermodynamic relations in the first chapter, introducing the concept of ideal solutions in the second, and finally dealing with real solutions in the third and fourth.

Although the content of Chapter 1 may be found in any text-book on thermodynamics, and will be considered elementary by most readers, it is useful to have such a summary of the relations to hand, and it also serves to introduce the symbols and nomenclature—we learn, for example, that the Gibbs free energy is to be referred to as the "free enthalpy". It is a pity that the chapter should be marred by the common student's error made in passing from expressions involving "number of moles" to those involving "mole fraction". In spite of the warning at the foot of page 10, the authors themselves fall into the trap on page 11 in obtaining equation I–47. The same error is made later in the first expression of equation I–255 on page 70, while equation I–257 on the same page is not deducible from equation I–148, but rather follows directly from equation I–147. In a similar way, equation I–141 on page 28 is in fact correct, and is not obtained, as stated, from the erroneous equation I–47. In all these cases, confusion would be avoided if the complete set of variables involved were given for each equation, rather than simply indicating the constancy of pressure and temperature. In Chapter 2, the properties of ideal solutions are adequately dealt with, and Chapter 3 introduces the concepts of activity and activity coefficient, and develops the relevant thermodynamic relations. The major part of Chapter 4 is concerned with integrations of the Gibbs–Duhem equation, and this is probably the most valuable section of the whole book. The treatment is systematized in the way first presented by Wohl, and forms an excellent summary of the many empirical relations now existing, including those due to Van Laar, Margules, Scatchard and Hamer, and Redlich and Kister. It is a pity that Wohl's own contribution is represented only by his earlier work, and that no mention is made of his 1953 paper. The value of this section is enhanced by the inclusion of many worked numerical examples of the application of these equations, together with comparisons of the results with direct experimental data, as well as a summarized presentation of all the relations in tabular form. Thus, although the authors have wisely refrained from attempting a general assessment of the relative values of these relations, they have made it easy for the reader to make his own comparisons for any specific case.

The authors show good practical sense in following up this survey with a discussion of methods for deriving complete equilibrium data from indirect measurements, again fully supported by numerical examples. Here one could perhaps wish for a little more discussion on the relative suitability of the methods for numerical solution of these particular differential equations, since two methods have been introduced somewhat arbitrarily in the examples. Some discussion of the magnitude of the errors involved in the different methods would also be welcome. On reading this chapter, one is left with the impression that, since the Gibbs–Duhem equation is obeyed, all the correlations are at least thermodynamically consistent. The limitation of the Gibbs–Duhem equation, as an expression of variation with composition of a single phase at constant pressure and temperature, is explicitly stated in the earlier chapters. However, as is frequently done, it is later assumed in some applications to hold along the equilibrium line, which for binary mixtures must involve variation of either temperature or pressure. It is only fair to the authors to say that in each case this assumption is noted, but its significance and the approximation involved are rarely sufficiently stressed, and are more often glossed over, as in the case of the derivation of the expressions for limiting relative volatilities on page 45.

In view of the detailed treatment accorded to these integrations of the Gibbs–Duhem equation, it is disappointing to find only a cursory treatment of alternative methods of correlating equilibrium data. The effect of non-ideality of the vapour phase is disposed of in less than eight pages, which also contain the only reference to equilibrium-ratios, or *K*-values. Surely the Benedict equation, and all that arises from it, is worth more than a passing reference? The law of corresponding states is illustrated by two numerical examples, but the treatment is wholly inadequate. The reader will find no mention of the 'convergence-pressure' concept, nor indeed is any indication given of the difficulties arising in correlating equilibrium data when the temperature is above the critical temperature of one or more of the components. Here the absence of vapour pressure makes impossible the application of the Gibbs–Duhem integrations, or even the ideal solution laws.

Part 2 is concerned with laboratory techniques, and should be considered as a review of a wide range of techniques, rather than as a detailed discussion and assessment of the different methods. The five chapters cover criteria of purity, temperature and pressure measurement, vapour pressure and vapour–liquid equilibrium determinations. In each case a good variety of techniques is presented, and, although there is seldom an adequate assessment of precision and the treatment is sometimes superficial—for example, the dead-weight piston pressure-balance is dealt with in six lines—there are usually sufficient references to the literature to enable one to obtain all the information required.

The authors state in their preface that they have deliberately avoided description of current laboratory equipment, and on these grounds have excluded thermostats. This does not seem logical for a book which includes chapters on measurement of temperature and pressure and discusses manostats in some detail. One cannot deny the usefulness of these in directing attention to points which so many workers overlook, and in view of the authoritative treatment

of methods of determination of vapour pressure and equilibrium compositions, one feels that the authors would have much to contribute on the special problems connected with thermostats. Many readers will be grateful for the extensive review of equilibrium stills, particularly because of the systematic method of classification employed, and the summarized comparison of them in a single table at the end of the chapter.

Part 3 consists of an alphabetical index to more than 1,200 references to original work on the experimental determination of equilibrium data. This impressive list is all the more valuable as it gives world-wide coverage of technical publications up to February 1957.

Although the book falls short of a comprehensive treatise and in its present edition has a number of shortcomings, it is nevertheless an outstanding contribution to the subject, and contains so much of solid worth that most workers in the field should learn something from its pages, and find it of constant value as a reference work. R. Sargent

TRANSISTOR ELECTRONICS

Junction Transistor Electronics

By Richard B. Hurley. Pp. xvii+473. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 100*s*. net.

Transistor Electronics

By Arthur W. Lo, Richard O. Endres, Jakob Zawels, Fred D. Waldhauer and Chung-Chih Cheng. Pp. xii+521. (London: Macmillan and Co., Ltd., 1958.) 45*s*. net.

On its own Hurley's book has a certain amount to commend: it is, however, difficult to understand the publishing policy of Messrs. John Wiley and Sons. About a year ago they published an excellent work on junction transistors edited by R. F. Shea, a book which received very favourable reviews. Hurley covers much the same ground as Shea, differing only in detail, and although I must admit his book is possibly designed more for use as a text-book, it cannot help being a competitor to Shea's work.

Introductory chapters on semi-conductor principles lead on to the small signal equivalent circuit of the transistor and the use of this circuit in the analysis of the transistor audio-amplifier. A chapter is devoted to bias stabilization and another to the application of negative feedback. The subject-matter of Chapter 6, "The Nature of Internal Noise Generation and Its Outward Effects", receives much better treatment than in Shea's book where it was dismissed, rather perfunctorily, in about a page.

The performance of a transistor under large signal conditions is considered and this leads to the problems of the design of power amplifiers. Direct-current amplifiers, video amplifiers, tuned amplifiers, automatic gain control, sinusoidal oscillators, modulation circuits all receive attention by way of separate chapters. Three more chapters deal with transistors in switching applications and in their use as relaxation oscillators.

Two rather special applications of the transistor, namely, in regulated power-supplies and saturable reactor-circuits, have individual chapters and receive a more detailed treatment than in Shea's work.

As a book for reference it suffers from the absence of a list of symbols, and what is more serious, although the author himself admits it, is the use of the same symbol with entirely different, and different shades of, meaning.

The presentation and reproduction is, of course, up to John Wiley's usual high standard.

The work on "Transistor Electronics" by Lo *et al.* is a reprint of a well-known book published in 1955 in the United States by Prentice-Hall. It has now been published in Britain by Macmillan, but the printing was carried out (and very well, too) in the Netherlands. So far as I can see there are no alterations to the original text. It covers substantially the same ground as Hurley's book but of course Hurley has three extra years development to include, and in a field that is subject to continual metamorphosis this gives him a considerable advantage.

The authors, who were all with the Radio Corporation of America when the book was written, favour the four-terminal network approach to the transistor equivalent circuit and deduce the performance in the various circuits using this as the basis. A very useful table shows the many varied forms the four-terminal equivalent network can take and will be very useful for reference. The book is intended both as a text-book for students of this subject and as a reference work, but I feel that it is in the former application that it will be most useful.

J. W. R. Griffiths

PROGRESS IN PHYSIOLOGY

Annual Review of Physiology

Vol. 21. Edited by Victor E. Hall, in association with Frederick A. Fuhrman and Arthur C. Giese. Pp. viii+636. (Palo Alto, Calif.: Annual Reviews, Inc.; and the American Physiological Society, 1959. On sale by Annual Reviews, Inc.) 7 dollars.

With the publication of Vol. 21, the "Annual Review of Physiology" comes of age, though it is still a mere fledgling to its 28-year sister publication, the "Annual Review of Biochemistry". Its growth over the years might be considered unphysiological, for its size at birth (705 pages) was greater than it is now (636 pages). The editorial committees have prevented the volume from becoming unmanageably large, but the question they raised last year remains unanswered: whether the present policy of "skimming one volumeful of physiological cream" can be continued indefinitely. With the growing output of research, it means that a progressively smaller proportion of the total published work is reviewed year by year. A similar problem exists for annual reviews in other subjects. Those who write the reviews are faced with the difficulty of selection. If they include too many papers in their survey, they tend to produce little more than an annotated card index, useful for reference but almost impossible to read through. If they select some of the more important recent work in their subject and give themselves room to discuss it, they produce a more interesting and stimulating review but may leave out a good deal of significant research. On the whole, the present reviewers have managed to make their summaries interesting to read and useful for reference.

The prefatory chapter is by A. V. Hill and deals with the heat production in muscle and nerve from

1848 (when Helmholtz made the first attempts at measurement) to the outbreak of the First World War. The chapter is preceded by a portrait of its author at work, complete with umbrella installed as a protection against floods from the laboratory above! Prof. Hill discusses some of the earlier work in the light of present-day knowledge and he includes reminiscences of research at Cambridge and of some of the people there and elsewhere who influenced him. It is good to know that this chapter will be the beginning of a future monograph.

This year's volume contains the usual chapters on the basic subjects, heart, peripheral circulation, respiration, digestion, kidney, water and electrolyte metabolism, the nervous system (four reviews) and reproduction. There are chapters on blood clotting, bone, transport through membranes, heat and cold, and chemical influences on cell division and development. Endocrinology this time covers the adenohypophysis and adrenal cortex, and the pancreas (insulin and glucagon).

The chapter on Russian physiology deals with metabolism and endocrinology. This is the last time that Soviet research will be treated separately. In future, reviewers will be encouraged to make use of the translations of Russian papers which are becoming increasingly available, and to discuss these papers along with the work from other countries. The final chapter, on comparative physiology, reviews work on the annual reproductive cycles of marine invertebrates.

The editorial committee pays its usual tribute to the authors (who write from six different countries) for undertaking the heavy task of preparing these surveys; all physiologists will wish to associate themselves with this tribute, and will wish the "Annual Review of Physiology" many further years of useful life.

D. C. HARRISON

RUMINATION

Metabolism in the Rumen

By E. F. Annison and D. Lewis. (Methuen's Monographs on Biological Subjects.) Pp. 184. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1959.) 15*s*. net.

THIS is an interesting, well-written and up-to-date account of the microbiology of digestion in the rumen and the resultant biochemical pathways of metabolism. In the rumen complex interactions take place which account for the importance of the ruminant in agriculture. Mammals do not secrete cellulases in their digestive juices, and the degradation of dietary cellulose in the rumen, its major function, is achieved by the cellulolytic activities of the microbial population. This releases potential substrates from refractory plant materials and permits the formation of metabolic end products in the rumen which are afterwards the main source of energy for the animal. This enables ruminants to live on coarse fibrous foods which would otherwise not be available. In other herbivora, such as the horse, there is a similar but more limited dependence on the activities of the micro-organisms of the cæcum.

The production of certain essential amino-acids and vitamins and the conversion of some dietary constituents into microbial substance are other metabolic transformations. Symbiotic relationships of a remarkable degree have thus been developed in the rumen. The separate metabolic pathways can seldom be adequately examined or controlled in isolation. The microbiol activities are delicately poised between catabolic and anabolic processes. Thus, for example, in protein metabolism the microbial contributions may range from a rapid breakdown of excess ingested protein to ammonia and volatile fatty acids, to the extreme synthetic phase whereby urea from the circulating blood may diffuse into the rumen and be used for the growth of cellulose fermenting bacteria. The techniques now becoming available to the biochemist, physiologist and microbiologist are enhancing their ability to study rumen function, one of the most fascinating and rewarding fields for their attention.

It is hoped that this book will help to dispel the considerable ignorance of many biochemists, physiologists and bacteriologists concerning what happens in the ruminant. The study of such animals should have its place in the normal curriculum of these subjects. While some of the pioneer work was set in motion by Tappeiner in Germany and by Schalk and Amadon in North Dakota, workers in the United Kingdom have made remarkable advances in this fascinating field, and the names of Baker, Barcroft, Phillipson, Elsden, Pearson, Smith, Oxford, McDonald, Synge and Chalmers are to be listed among the pioneers. But Marston in Australia, Hungate, Bryant, Doetsch, Gall and Huhtanen in the United States, Balch, Blaxter and Hobson in Great Britain have, among many others, made their mark. The authors, too, have justified their position to be knowledgeable authorities in this field.

D. P. CUTHBERTSON

DEVELOPMENTAL BIOLOGY

The Developmental Biology Conference Series, 1956

Cytodifferentiation. Edited by Dorothea Rudnick. Pp. xi+148. 28*s*. net. Environmental Influences on Prenatal Development. Edited by Beatrice Mintz. Pp. xiii+87. 22*s*. 6*d*. net. Regeneration in Vertebrates. Edited by Charles S. Thornton. Pp. xi+108. 52*s*. 6*d*. net. Embryonic Nutrition. Edited by Dorothea Rudnick. Pp. xi+113. 24*s*. net. Immunology and Development. Edited by M. V. Edds, Jr. Pp. xi+59. 19*s*. net. Dynamics of Proliferating Tissues. Edited by Dorothy Price. Pp. xv+96. 24*s*. net. Wound Healing and Tissue Repair. Edited by W. Bradford Patterson. Pp. xi+83. 21*s*. net. (The Developmental Biology Conference Series, 1956, held under the auspices of the National Academy of Sciences—National Research Council.) (Chicago: University of Chicago Press; London: Cambridge University Press, 1959.)

A LIVING organism has a present and two pasts, one evolutionary and the other ontogenetic. A study of any one of the three is ultimately comprehensive and will embrace the other two; any knowledge of one must be relevant to the others; and yet to each there is a distinctive biological approach.

The developmental biology conference series, a marathon of discussion meetings held in the United States with international participation in 1956, can be said to mark the end of a period during which the developmental approach to biology has been

establishing its aims and staking its frontiers. Embryology, in the strict sense, is no longer granted automatic precedence, nor is morphogenesis the key problem. Events in any part of the ontogenetic cycle are seen in terms of the contribution they can make to an understanding of the whole.

These meetings were thus, if anything, even less restricted in scope than might be suggested by the titles of the volumes in which they are reported. Though there is remarkably little repetition of one in another, between them they touch upon a substantial fraction of all experimental biology. However, it was not intended that the series should be comprehensive and there are, inevitably, many gaps, some premeditated and others contingent upon the informal nature of the discussions. This is not a fault, but it does mean that some of the reports will be of most value to those already familiar with the background to the themes discussed. This is true, for example, of "Cytodifferentiation" and of "Environmental Influences on Prenatal Development", both of which contain stimulating presentations of recently discovered facts and recently developed ideas. On the other hand, the more formal reviews in "Regeneration in Vertebrates" provide excellent and comprehensive surveys of a few selected experimental situations.

These seven volumes do indeed vary greatly in character, partly because the meetings themselves took different forms and partly by editorial decision. At the one extreme (for example, in "Embryonic Nutrition") we are offered an orthodox sequence of papers and discussions of them, with a complete list of the authorities referred to. At the other (in "Immunology and Development") the identities of discussion leaders, participants, and absent authorities are not defined and their work is merged into a sort of collective stream-of-consciousness report. Both volumes are successful, but their usefulness is clearly of different kinds.

Formal considerations apart, it must be confessed that the series, viewed as a whole, lacks the intellectual coherence that the "unity of subject matter" claimed for it by its organizer, Paul Weiss, might lead one to expect. We have not yet a continuous spectrum of problems in developmental biology. But these meetings certainly reflected real progress towards a consciously unified approach to developmental processes, a progress that will be further stimulated by the publication of their proceedings.

D. R. Newth

THE HETEROGENEITY OF HUMAN HÆMOGLOBIN

Abnormal Hæmoglobins

A Symposium Organized by the Council for International Organizations of Medical Sciences. Edited by J. H. P. Jonxis and J. F. Delafresnaye. Pp. ix+427. (Oxford: Blackwell Scientific Publications; Springfield, Ill.: Charles C. Thomas, 1959.) 45*s*. net.

THIS volume contains the papers and discussions of a symposium on abnormal hæmoglobins held in Istanbul in September 1957. Since Pauling's demonstration in 1949 of an electrophoretically distinct hæmoglobin in sickle-cell anæmia, the discovery of new variants has proceeded with increasing momentum so that, at present, 15 hæmoglobins have been designated by letters of the alphabet. Four subfractions of normal adult human hæmoglobins, A_1, A_2, A_3, A_4 (A_2'), and one normal fœtal hæmoglobin are now known. The complexity of the situation is illustrated by reports of a further seven variants which are given provisional names derived from the place of discovery, in order to avoid confusion of the nomenclature.

The interest in abnormal hæmoglobins is spreading throughout the world, and involves many scientific disciplines. It is this widespread multidisciplinary interest which has brought the subject within the ambit of the Council for International Organizations of Medical Sciences. Participants in the symposium included eminent workers of international repute, and others who have become recognized for their work in their own geographical localities. The papers have been grouped under two main headings: "Biological Considerations" and the "Geography of Hæmoglobins". Itano (United States) opens the symposium with an introductory discourse on the "Genetic and Physical Factors in the Heterogeneity of Hæmoglobin". The identification of human hæmoglobins is described by Huisman (Holland), though practical details of technique are not given. This paper is supplemented by Cabannes and Portier (Algiers) with a description of their electrophoretic experiences of the newly discovered hæmoglobins. Two groups of workers using two different techniques bring forth evidence that the alkali-resistant hæmoglobin of thalassæmia is not fœtal hæmoglobin: a view not held by the majority of authorities. Derrien (France) bases his evidence on solubility experiments, while Dianoco and Castay (Tunis) describe immunological differences using a complement fixation test for the detection of hæmoglobin antibodies. Clinical and hæmatological aspects of the various hæmoglobin syndromes are described by Zuelzer (United States). Chapters on fœtal and sickle cell hæmoglobin are provided by Jonxis (Holland) and Vandepitte (Belgian Congo) respectively. Fessas (Greece) described the alterations of the hæmoglobin pattern in thalassæmia. The first section is concluded by chapters on the genetic aspects by Neel (United States) and on the hæmoglobin types of animals by Huisman (Holland) and his colleagues.

In the part on geography, the following authors have dealt with the position of abnormal hæmoglobins in their region: Aksoy (Turkey), Pouya (Iran), Silvestroni and Bianco (Italy), Fessas (Greece), Vandepitte (Belgian Congo), Portier, Cabannes and Duzer (Algiers), Edington (Ghana), Chatterjea (India), de Silva, Jonxis and Wickramasinghe (Ceylon), Na-Nakorn (Thailand), and Lie-Injo Luan Eng (Indonesia). Prof. Jonxis contributes some interesting comparisons of the frequencies of the sickle-cell and hæmoglobin *C* traits in the Dutch colonies of Curacao and Surinam. Two chapters by Lehmann (United Kingdom) put the subject of hæmoglobin variants in their proper geographical perspective.

The nomenclature of the newer hæmoglobin variants *H–N* is given in an appendix, together with the studies required before a new hæmoglobin can be designated.

This volume will provide a useful account of the abnormal hæmoglobin situation up to early 1958, whether the reader be a hæmatologist, physician, biochemist, geneticist or anthropologist.

J. A. M. Ager

A Handbook of Lattice Spacings and Structures of Metals and Alloys

By Dr. W. B. Pearson. (International Series of Monographs on Metal Physics and Physical Metallurgy, Vol. 4.) Pp. x+1044. (London and New York: Pergamon Press, 1958.) 262*s*. 6*d*.

THIS is a formidable work of more than 1,000 pages. It is divided into two parts. The first part is an account of the methods used in the accurate determination of lattice spacings and crystal structures, and of the significance of the results in connexion with the location of phase boundaries, the application of electron theory to metals and alloys, and the effect of magnetic properties on lattice spacings. A brief mention is also made of the role of lattice parameter measurements in miscellaneous fields such as thermal expansion and superconductivity.

The second part occupies most of the book, and consists of a collection of crystallographic data. This includes the lattice spacings and crystal structures of the elements, of binary, ternary and quaternary alloys, and of borides, hydrides, carbides, nitrides and oxides. The largest section in this part is an alphabetical index of the work on metals and alloys. For each alloy system a brief description of the equilibrium diagram is given, together with a critical assessment of the various lattice parameters obtained by different workers. Sufficient practical information on the methods of obtaining the data is given to make it unnecessary in most cases to refer to the original papers. References are included up to 1957.

The labour involved in producing this work must have been considerable, and the author is to be congratulated on the result. It will prove to be of great value to the research worker, and should be in the library of all people who are interested in the physics of metals. The book is unfortunately very expensive.

J. A. CATTERALL

The Birds of Sydney (County of Cumberland), New South Wales

By K. A. Hindwood and A. R. McGill. Pp. iii+128+19 plates. (Sydney: Royal Zoological Society of New South Wales, 1958.) 12*s*. 6*d*.

THE Sydney Basin is essentially Triassic in origin and was formed by successive lake deposits overlying coal measures of Permian age. Above the coal is red shale, and above this there lies a tough sandstone surmounted by a final capping of grey shale. Here and there erosion has bared the underlying structures; in fact, the city of Sydney is built on and partly of Hawkesbury sandstone. Each geological type supports its own characteristic flora and, correspondingly, fauna. The red shale of the deep valleys has attracted an Indo-Malayan vegetation, as well as a fauna partly of northern affinity. The flowering heaths of the sandstone support many honey-eating animals and others; and in the open forests of the surviving top-shale is found a fauna which is often closer allied to that of the dry interior than to the animals in the cool valleys nearby.

Messrs. Hindwood and McGill have compiled a useful list of the 377 species of birds—both land and marine—native to this zoologically fascinating region. Under each name are five or six lines, mentioning salient points of description and the localities in which each species can be found. The compilation, therefore, remains of strictly local interest; and this is a pity. The area abounds with problems relating to the wider aspects of avian zoogeography, ecology and dispersal and it is regrettable that no attempt has been made to get to grips with such matters. The book is illustrated with a map of the area and excellent photographs of about thirty species.

A. J. MARSHALL

Food for Survival after a Disaster

By Dr. R. C. Hutchinson. Pp. ix+90+6 plates. (Carlton, N.3: Melbourne University Press; London: Cambridge University Press, 1959.) 13*s*. 6*d*.

THE disaster envisaged in the title is that of shipwreck, forced plane landing, or vehicle breakdown in a desert area, rather than the large-scale disaster of modern war, and the information given is primarily that which would be of the greatest value to individuals or small groups of survivors trying to keep alive under adverse conditions in strange surroundings. In addition to this, however, the book also contains much pertinent detail on de-salting kits and on the selection and packaging of survival rations which would be of great use to those planning scientific expeditions and to commercial shipping and air-line companies who may not have access to pamphlets prepared for the Armed Forces.

The author claims to speak from personal experience as "a survivor on both land and sea", and has certainly condensed a wealth of material into a very small space and presented it in a most readable form. The chapter on "Possible Supplementary Sources of Food" is a whole lesson in ecology in itself and one that should stimulate the interest of any school-boy. Decidedly a book to be recommended to all inveterate travellers: the day might well come when they would owe their lives to what they had learnt from its pages.

M. W. GRANT

From Microphone to Ear

Modern Sound-Recording and Reproduction Technique. By G. Slot. Second, revised and enlarged edition. Pp. ix+258. (Eindhoven: Philips' Technical Library; London: Cleaver-Hume Press, Ltd., 1959.) 21*s*.

THIS book might well be entitled "Gramophones, from *A* to *Z*", for it seems to contain everything, even (p. 82) how to remove gin spots from your records! It is obviously written by an enthusiast for enthusiasts, and its quality has been well preserved in the excellent translation. Many an amateur constructor, 'hi-fi' or stereophony fan, or even the intelligent listener with a curiosity to learn more of what gets the music on to the records and out of the loudspeaker, will find plenty of reading here. Recording techniques, studio work, tracking theory, loudspeaker dynamics, cabinet design, motor construction, care of records, negative feedback, tape recorders, sound effects, automatic record changers, needles, hum—the lot.

With this enormous coverage the treatment of much of the material will seem shallow to professionals and it would be easy to be critical, but purposeless. The book is informative, practical, well written and illustrated by many simple line diagrams and photographs. It makes a welcome and timely appearance, in these days of such increased demand for better musical recording and reproduction. Many enthusiasts want to assess the merits of this technique and that, or to judge the quality of their equipment, or to improve it; this book will help them.

COLIN CHERRY

ELECTRONIC PREDICTION OF SWARMING IN BEES

By E. F. WOODS*

THE honey bee is one of man's two domesticated insects (the other being the silkworm), and has been cultivated before the dawn of history, principally for the production of honey. The primitive method of beekeeping revolved around the instinct of bees to swarm. Each colony produced by swarming 6–15 new colonies, usually in spring, and those colonies were hived and allowed to build up in the summer, gathering and storing honey. In the autumn, all but one of the colonies resulting from one mother colony were destroyed, and the honey and wax harvested. The remaining colony repeated the cycle next year. This system is still in use in some countries, such as Abyssinia, Palestine, and India, but is rapidly falling into disuse.

In 1851, Langstroth, in the United States of America, introduced the movable-frame hive and found that, if swarming could be prevented, the quantity and quality of the honey were enormously improved. But the difficulty lay in preventing swarming, the bees' natural method of reproduction, and for a century the only method known has been meticulously to examine all colonies at regular intervals, and take appropriate action with those showing visible signs of an impending swarm, namely, queen cells. This examination is made on each colony every 9 or 10 days from about mid-April to mid-July—about eight operations in a season—and takes 5–10 min. for a skilled operator, who must be physically robust, since he has to lift the components of a hive weighing up to 60 lb. each. The repeated disturbance to the bees seriously reduces the honey crop. Moreover, since only about 3 per cent of the colonies show signs of swarming, 97 per cent of this work is wasted. When it is realized that this system is applied to more than 10,000,000 colonies of bees throughout the world—more than 5,000,000 in the United States alone—the tremendous waste of labour and honey becomes obvious. This system is costly in labour (about £3 per colony per annum), and the loss of honey due to disturbance is also considerable, quite comparable in value with the actual outlay in labour.

My work on the analysis of the sounds of activity in the hive indicated that small variants of the normal sound could be identified which were indicative of abnormality. Certain characteristic sounds in particular were found to be adequate criteria for, among other possibilities, the prediction of swarming. A technique was therefore developed, and an instrument designed and produced for monitoring the condition and behaviour of a colony with no disturbance to the bees whatsoever.

An analysis of the sound spectrum of a large healthy colony of bees, in three conditions, is given in Fig. 1, curves I, II and III. These curves were obtained by two methods: by selecting the wanted sound by means of a filter circuit and relating it by ear to a similar pure tone, attenuated; and by the use of a standard wave-analyser. The two methods gave similar results, and the second was adopted, being much simpler and quicker. As no absolute standard is available, all sounds were related to the loudest, the flight noise.

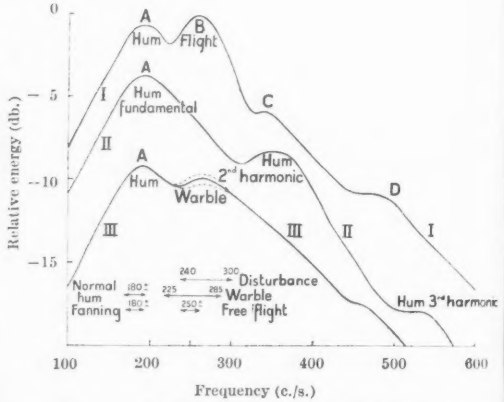

Fig. 1. *Apis mellifica*, same colony July 7–8, 1959
I, 2 p.m., harvesting; II, 2 a.m., no flight; III, deprived of fliers and dequeened

Fig. 1, curve I, represents the normal day-time spectrum. *A* is the basic sound produced by the action of the spiracular valves on the inspired and expired air, varying for an individual bee in synchronism with the breathing movements, but amounting *en masse* to a steady hum at 180 ± 5 c./s. *B* shows the flight sound, with a frequency of 250 ± 1 c./s. *C* and *D* are harmonics of *A* and *B*, merging at high frequencies. There is no supersonic component.

Fig. 1, curve II, refers to the same colony after dark. The general sound is weaker, and the flight component is missing. Curve III is from the same colony, deprived of fliers, and with the queen removed, the recording having been taken 3 hr. after her removal. The important component at 225–285 c./s. will be noted, varying somewhat in frequency, but not more than $\pm$ 3 db. in volume, which has built up steadily to a maximum. It is almost a true warble technically so defined.

This warble is a consequence of the removal of the queen, and the time at which it appears varies with several factors: (*a*) the smaller the colony the shorter the time and vice versa; (*b*) the busier the colony, the longer it takes to appear; (*c*) the presence of numerous nurses at certain times of the year shortens the period; (*d*) the period varies with different breeds of bee, the more 'phlegmatic' dark bees tending to have slower reactions.

The warble not only increases in volume, building up relatively steadily to a peak, but its nature also changes. For a typical time of 5 hr. from removal of the queen to maximum sound, the process would be as follows.

0–10 *min.* A faint, steady rise and fall in the frequency-range 225–285 c./s., made by the nurse bees immediately attendant on the queen, probably those obtaining queen substance from her.

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10 *min.*–3 *hr.* A bubbly, jerky sound, in the same frequency-range, somewhat plaintive. The bees act as if distressed, and are very subdued in behaviour.

3–5 *hr.* The warble, still in the range quoted, becomes more jerky and fierce. The bees become irritable.

5 *hr.* The sound becomes a twanging sound, and at this point the bees tend to become intractable and fierce. Queen cells appear.

After 5 *hr.* The warble disappears in a few minutes and is replaced by the 'roar', a sound of frequency 180 ± 2 c./s., varying in volume by ± 20 db. The bees are now usually intractable and vicious.

At any time during the warbling, the queen can be replaced with little risk of loss, and at the peak, her acceptance by the colony is almost certain. After the cessation of the warble, introduction of a queen is almost impossible.

A large number of experiments over several years showed that the warble was produced by nurse bees, aged 4½–6 days, and that it could be related very accurately to their inability to dispose of the royal jelly, automatically produced at this age. This general explanation covered every observation of the occurrence of the warble at any season and in all conditions.

Partial slowing down of oviposition occurs during the 'fining down' of the queen in the pre-swarm period, giving rise to a progressively increasing warble as more and more nurse bees are thrown out of work, but it has not hitherto been noticed, because not only is it very weak, but also the fliers which comprise the swarm, no longer stimulated to fly for harvest, remain in the colony and increase the normal sound.

It therefore appeared that an increasing warble should be detectable from the start of swarm-preparation, and that a means of detecting it might afford a means of predicting the onset of swarming.

It will, however, be obvious from the curves that this sound, at its very loudest, and with fliers removed, is 10 db. below the general noise-level, and is never clearly audible to the unaided ear until the swarm has left the hive.

A filter amplifier circuit was therefore constructed, reducing all frequencies outside the range 255 ± 30 c./s., and providing considerable amplification to the residue, and it was found that the warble was distinguishable as much as 25 days before the issue of the swarm, and clear and unmistakable about 15 days before swarming. Thus with a suitable instrument, the onset of swarming can be predicted a week or more before the visible signs—namely, queen cells—are laid down, and a fortnight before the issue of the swarm.

A complication arises in that many, probably most, colonies supersede a failing queen at least once, the daughter mating and ovipositing before the mother is destroyed (by the bees). There is thus only a small decrease in egg production, but the progressive failure of the old queen, reducing the supply of queen substance, has an effect similar to egg reduction, and the nurses warble, a sound weaker but in no way different from the pre-swarm warble. It is, however, quite easy to determine which process is in prospect. If a colony be disturbed, it produces a characteristic hiss, and if the colony is in breeding-balance, that is to say, the eggs and young larva are fairly well equated to the nursing potential, this is a short vicious sound, lasting only tenths of a second before ceasing. To get this 'shape' of sound, the stimulus

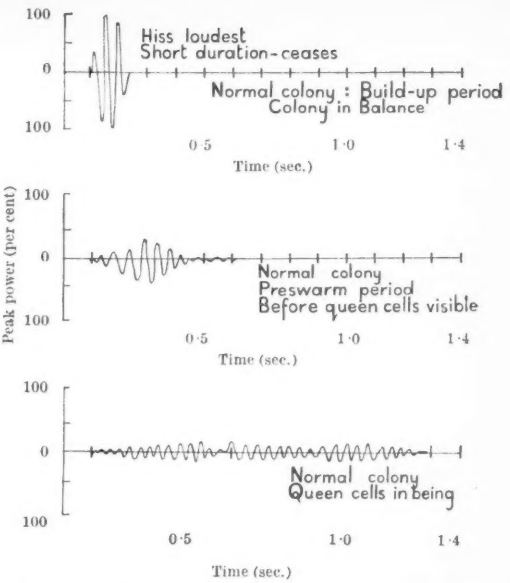

Fig. 2. Hiss (diagrammatic). In the queen cell-in-being diagram (bottom) the duration grows to 10 sec. or more and the power vanishes to zero

must be short and apply to all bees : a jerk on the hive suffices. If the number of eggs is falling relatively to the nursing potential, the sound has the same character, but is reduced in peak volume and lengthened in time. With a little practice it is easy to distinguish an incipient swarm from supersedure.

To permit the reliable assessment of the hiss—a random spectrum of sound from about 3,000 c./s. upwards—a second filter was constructed. The hiss was then amplified and presented to the ear in unmistakable volume. Fig. 2 illustrates the hiss cycle. It should be noted that Fig. 1 represents actual measurements on a typical colony, whereas Fig. 2 is diagrammatic.

Fig. 3 shows the progress of a pre-swarm cycle. The build up of warble can be regarded as typical, but it should be understood that it varies both in frequency, that is, it warbles, and also from instant to instant in volume. The frequency excursion is now quite definite, from 225 to 285 c./s., but the instantaneous variation in volume seems to be unpredictable. However, the average volume rises steadily as shown (Fig. 3).

The practical utilization of these sounds requires an instrument which not only selects and amplifies them, but is also simple to operate, robust, cheap and weatherproof. It must also be battery driven. The recent development of transistors and 'Ferroxcube' inductors has enabled these stringent requirements to be fulfilled in an instrument patented under the name 'Apidictor'[1], of which a number have been constructed and are in regular use.

Early models were portable, with a microphone on a probe, to be inserted in the entrance to the hive at the bottom of the brood-box. This caused some disturbance, the stinging reaction, and also the instrument was necessarily close to the flight sound. Both these sounds are in the warble frequency-range, and considerable skill was needed to distinguish the

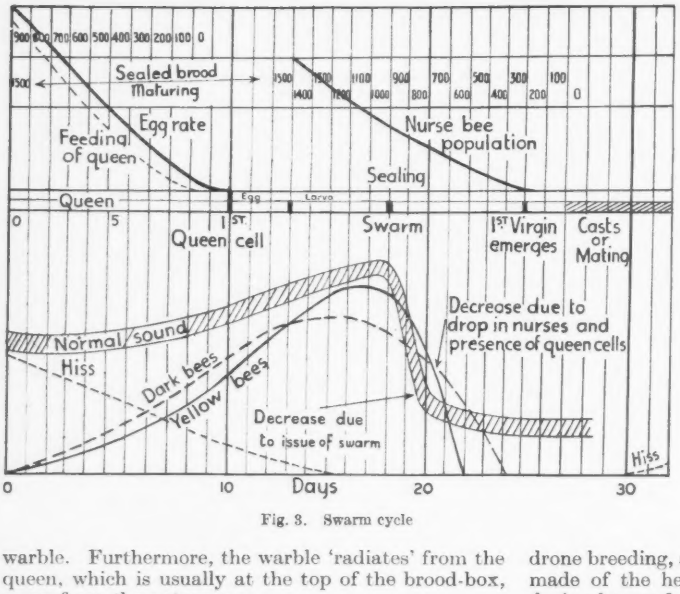

Fig. 3. Swarm cycle

warble. Furthermore, the warble 'radiates' from the queen, which is usually at the top of the brood-box, away from the entrance.

Disturbance was eliminated, and the relative volume of the warble increased by placing a microphone permanently inside the hive at the top, but the adverse conditions of heat and humidity destroyed the (crystal) microphone fairly quickly, and the running cost of one microphone per hive per season was excessive.

A scheme which has proved successful and economical utilizes a hole in the back of the brood-box at the top, with an internal screen of perforated zinc, and plugged with a rubber bung. This bung is removed and the microphone, mounted in an identical bung, plugged in. This third plan also removes a disadvantage of the second, namely, the variability of microphones, especially after some weeks in the hive.

Headphones, of the familiar stethophone pattern, are used as a detector, but later development may permit the use of a visual indicator, at an increased cost. An automatic alarm system is also possible for use in large centralized apiaries.

The 'Apidictor' was primarily visualized as a swarm predictor, for which it has obvious economic advantages, but it has a great range of other uses. It removes almost completely the uncertainty of queen introduction and queen cell acceptance, it detects abnormalities such as queen failure, that is, drone breeding, and it enables an accurate check to be made of the health of the colony in winter, even during heavy frost.

I wish to acknowledge the enthusiastic and skilled co-operation of many friends, but particularly of Mr. E. F. Birch of Hereford, who has been working with me since 1951, and of Mr. C. B. Dennis of Harrow, who has co-operated with me for the past three years. I also wish to thank Messrs. Wayne Kerr Laboratories of Surrey, for invaluable technical assistance.

[1] British Patent No. 729,067 (1958).

SEARCHING FOR INTERSTELLAR COMMUNICATIONS

By GIUSEPPE COCCONI* and PHILIP MORRISON†
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NO theories yet exist which enable a reliable estimate of the probabilities of (1) planet formation; (2) origin of life; (3) evolution of societies possessing advanced scientific capabilities. In the absence of such theories, our environment suggests that stars of the main sequence with a lifetime of many billions of years can possess planets, that of a small set of such planets two (Earth and very probably Mars) support life, that life on one such planet includes a society recently capable of considerable scientific investigation. The lifetime of such societies is not known; but it seems unwarranted to deny that among such societies some might maintain themselves for times very long compared to the time of human history, perhaps for times comparable with geological time. It follows, then, that near some star rather like the Sun there are civilizations with scientific interests and with technical possibilities much greater than those now available to us.

To the beings of such a society, our Sun must appear as a likely site for the evolution of a new society. It is highly probable that for a long time they will have been expecting the development of science near the Sun. We shall assume that long ago they established a channel of communication that would one day become known to us, and that they look forward patiently to the answering signals from the Sun which would make known to them that a new society has entered the community of intelligence. What sort of a channel would it be?

The Optimum Channel

Interstellar communication across the galactic plasma without dispersion in direction and flight-time is practical, so far as we know, only with electromagnetic waves.

Since the object of those who operate the source is to find a newly evolved society, we may presume that the channel used will be one that places a minimum burden of frequency and angular discrimi-

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nation on the detector. Moreover, the channel must not be highly attenuated in space or in the Earth's atmosphere. Radio frequencies below ~1 Mc./s., and all frequencies higher than molecular absorption lines near 30,000 Mc./s., up to cosmic-ray gamma energies, are suspect of absorption in planetary atmospheres. The bandwidths which seem physically possible in the near-visible or gamma-ray domains demand either very great power at the source or very complicated techniques. The wide radio-band from, say, 1 Mc. to 10^4 Mc./s., remains as the rational choice.

In the radio region, the source must compete with two backgrounds: (1) the emission of its own local star (we assume that the detector's angular resolution is unable to separate source from star since the source is likely to lie within a second of arc of its nearby star); (2) the galactic emission along the line of sight.

Let us examine the frequency dependence of these backgrounds. A star similar to the quiet Sun would emit a power which produces at a distance R (in metres) a flux of:

$$10^{-15} f^2/R^2 \quad \text{W.m.}^{-2}\text{(c./s.)}^{-1}$$

If this flux is detected by a mirror of diameter l_d, the received power is the above flux multiplied by l_d^2.

The more or less isotropic part of the galactic background yields a received power equal to:

$$\left(\frac{10^{-12.5}}{f}\right)\left(\frac{\lambda}{l_d}\right)^2 (l_d)^2 \quad \text{W.(c./s.)}^{-1}$$

where the first factor arises from the spectrum of the galactic continuum, the second from the angular resolution, and the third from the area of the detector. Thus a minimum in spurious background is defined by equating these two terms. The minimum lies at:

$$f_{\text{min.}} \approx 10^4 \left(\frac{R}{l_d}\right)^{0.4} \text{ c./s.}$$

With $R = 10$ light years $= 10^{17}$ m. and $l_d = 10^2$ m., $f_{\text{min.}} \approx 10^{10}$ c./s.
The source is likely to emit in the region of this broad minimum.

At what frequency shall we look? A long spectrum search for a weak signal of unknown frequency is difficult. But, just in the most favoured radio region there lies a unique, objective standard of frequency, which must be known to every observer in the universe: the outstanding radio emission line at 1,420 Mc./s. (λ = 21 cm.) of neutral hydrogen. It is reasonable to expect that sensitive receivers for this frequency will be made at an early stage of the development of radio-astronomy. That would be the expectation of the operators of the assumed source, and the present state of terrestrial instruments indeed justifies the expectation. Therefore we think it most promising to search in the neighbourhood of 1,420 Mc./s.

Power Demands of the Source

The galactic background around the 21-cm. line amounts to:

$$\frac{dW_b}{dS\ d\Omega\ df} \approx 10^{-21.5} \quad \text{W.m.}^{-2}\ \text{ster.}^{-1}\ \text{(c./s.)}^{-1}$$

for about two-thirds of the directions in the sky. In the directions near the plane of the galaxy there is a background up to forty times higher. It is thus economical to examine first those nearby stars which are in directions far from the galactic plane.

If at the source a mirror is used l_s metres in diameter, then the power required for it to generate in our detector a signal as large as the galactic background is:

$$\frac{dW_s}{df} = \frac{dW_b}{dS\ d\Omega\ df}\left(\frac{\lambda}{l_s}\right)^2\left(\frac{\lambda}{l_d}\right)^2 R^2 = 10^{-24.2}\ R^2/l_s^2 l_d^2 \quad \text{W.(c./s.)}^{-1}$$

For source and receiver with mirrors like those at Jodrell Bank ($l = 80$ m.), and for a distance $R \simeq 10$ light years, the power at the source required is $10^{2.2}$ W.(c./s.)$^{-1}$, which would tax our present technical possibilities. However, if the size of the two mirrors is that of the telescope already planned by the U.S. Naval Research Laboratory ($l = 200$ m.), the power needed is a factor of 40 lower, which would fall within even our limited capabilities.

We have assumed that the source is beaming towards all the sun-like stars in its galactic neighbourhood. The support of, say, 100 different beams of the kind we have described does not seem an impossible burden on a society more advanced than our own. (Upon detecting one signal, even we would quickly establish many search beams.) We can then hope to see a beam toward us from any suitable star within some tens of light years.

Signal Location and Band-Width

In all directions outside the plane of the galaxy the 21-cm. emission line does not emerge from the general background. For stars in directions far from the galactic plane search should then be made around that wave-length. However, the unknown Doppler shifts which arise from the motion of unseen planets suggest that the observed emission might be shifted up or down from the natural co-moving atomic frequency by $\pm$~300 kc./s. ($\pm$100 km. s.$^{-1}$). Closer to the galactic plane, where the 21-cm. line is strong, the source frequency would presumably move off to the wing of the natural line background as observed from the direction of the Sun.

So far as the duration of the scanning is concerned, the receiver band-width appears to be unimportant. The usual radiometer relation for fluctuations in the background applies here, that is:

$$\frac{\Delta B}{B} \propto \sqrt{\frac{1}{\Delta f_d \cdot \tau}}$$

where Δf_d is the band-width of the detector and τ the time constant of the post-detection recording equipment. On the other hand, the background accepted by the receiver is:

$$B = \frac{dW_b}{df}\ \Delta f_d \text{ and } \tau \propto \frac{\Delta f_d}{(\Delta B)^2}$$

If we set ΔB equal to some fixed value, then the search time T required to examine the band F within which we postulated the signal to lie is given by:

$$T = \frac{F\tau}{\Delta f_d} \propto \frac{F}{(\Delta B)^2}$$

independent of receiver band-width Δf_d.

Of course, the smaller the band-width chosen, the weaker the signal which can be detected, provided $\Delta f_d \geqslant \Delta f_s$. It looks reasonable for a first effort to choose a band-width Δf_d normal in 21 cm. practice, but an integration time τ longer than usual. A few

settings should cover the frequency range F using an integration time of minutes or hours.

Nature of the Signal and Possible Sources

No guesswork here is as good as finding the signal. We expect that the signal will be pulse-modulated with a speed not very fast or very slow compared to a second, on grounds of band-width and of rotations. A message is likely to continue for a time measured in years, since no answer can return in any event for some ten years. It will then repeat, from the beginning. Possibly it will contain different types of signals alternating throughout the years. For indisputable identification as an artificial signal, one signal might contain, for example, a sequence of small prime numbers of pulses, or simple arithmetical sums.

The first effort should be devoted to examining the closest likely stars. Among the stars within 15 light years, seven have luminosity and lifetime similar to those of our Sun. Four of these lie in the directions of low background. They are τ Ceti, 0_2 Eridani, ε Eridani, and ε Indi. All these happen to have southern declinations. Three others, α Centauri, 70 Ophiucus and 61 Cygni, lie near the galactic plane and therefore stand against higher backgrounds. There are about a hundred stars of the appropriate luminosity among the stars of known spectral type within some fifty light years. All main-sequence dwarfs between perhaps $G0$ and $K2$ with visual magnitudes less than about $+6$ are candidates.

The reader may seek to consign these speculations wholly to the domain of science-fiction. We submit, rather, that the foregoing line of argument demonstrates that the presence of interstellar signals is entirely consistent with all we now know, and that if signals are present the means of detecting them is now at hand. Few will deny the profound importance, practical and philosophical, which the detection of interstellar communications would have. We therefore feel that a discriminating search for signals deserves a considerable effort. The probability of success is difficult to estimate ; but if we never search, the chance of success is zero.

METABOLIC CHANGES INDUCED IN MAMMALIAN ERYTHROCYTES BY WHOLE-BODY X-IRRADIATION

By Prof. D. A. RAPPOPORT and B. W. SEWELL
Department of Biochemistry, Baylor University College of Medicine, Houston, Texas

APPLICATION of X-rays and radium in medicine, after their discovery during 1895–96, established their effectiveness in diagnosis and treatment of disease. Only somewhat later were the lethal and injurious properties of these penetrating rays recognized[1]. Since then, large groups of men have become exposed more frequently to man-made radiation. These additional exposures to penetrating radiation have magnified the need for a reliable indicator of radiation-induced tissue damage. What is precisely needed is a simple and accurate indicator which would correlate biological damage with the radiation dose[1].

The requirements of an ideal biological radiation indicator are that : (*a*) a tissue or tissue component should show changes over extended periods following whole-body irradiation ; (*b*) this change can be quantitatively measured. It is also important that tissue samples should be available for intermittent sampling without injury to the subject and without alteration in the system under examination.

Choice of Erythrocytes

Certain generalizations can be used in considering this problem in order to initiate a working hypothesis. Tentatively it can be assumed that any radiation absorbed by cells will cause changes in the cell enzymes[2], but that the detection of these changes is dependent on (*a*) the sensitivity to radiation of a particular enzyme system under evaluation and (*b*) the degree of sensitivity of the analytical methods employed.

Implicit in the above specifications is the fact that the tissue must be incapable of extensive internal repair if it is to reflect any post-irradiation changes. This immediately eliminates tissues with large populations of mitotic cells and suggests erythrocytes as the tissue component of choice. In man the erythrocyte has a life-span of 110–120 days[3], in the rat this span is 49–55 days[4], in other mammals erythrocyte life-spans are between these values[5]. Since mammalian erythrocytes are enucleated, no resyntheses of proteins can occur, and any radiation damage incurred on the enzyme-proteins, such as denaturation or rupture of peptide linkage, should be detectable by changes in enzymic reactions. This rationale suggests the erythrocyte enzymes for examination as a test system.

If the hypothesis is held that any absorbed radiation will affect enzymes in all cells, how is it that no enzymic changes have been observed in erythrocytes after moderate whole-body irradiation ? This may be explained on the basis that up to the present time few erythrocyte enzymes have been tested after radiation treatment. Erythrocyte enzymology has now been more thoroughly explored[6,7]. With the complete elucidation of glycolysis, the hexosemonophosphate shunt, the transketolase and transaldolase enzymes, and nucleoside phosphorylase in erythrocyte extracts, re-examination of the radiation effect on these enzyme systems is in order.

Nucleoside Metabolism

Investigators concerned with the preservation of blood have found that when inosine or adenosine is added to blood the integrity of the erythrocytes is maintained during storage and their survival following transfusion is improved[8]. This was attributed to the resynthesis of metabolites essential for erythrocyte integrity.

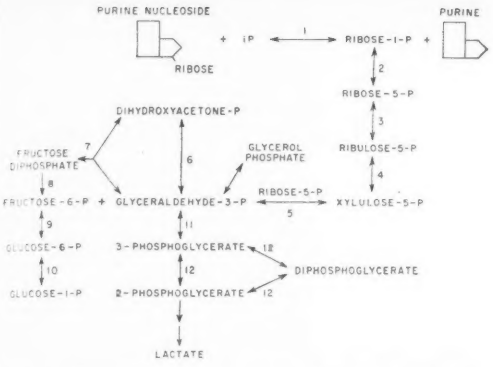

Fig. 1. Diagrammatic representation of the metabolic reactions of purine nucleosides in erythrocytes. The enzymes involved are: (1) nucleoside phosphorylase; (2) phosphoribomutase; (3) paosphoriboisomerase; (4) phosphoketopentoepimerase; (5) transketolase; (6) triosephosphate isomerase; (7) aldolase; (8) fructose diphosphatase; (9) phosphoglucoisomerase; (10) phosphoglucomutase; (11) triosephosphate dehydrogenase; (12) phosphoglyceric mutase

The enzymes responsible for nucleoside metabolism within the erythrocyte are in the soluble portion of the cell. The reactions which they catalyse are diagrammatically illustrated in Fig. 1. First, the nucleoside in presence of phosphate is converted to ribose-1-phosphate and a purine base by a nucleoside phosphorylase[9]. Later, the pentose phosphate is transformed to a variety of phosphate esters via the actions of transketolase, transaldolase and the glycolytic enzymes[6].

When considering nucleoside metabolism in erythrocytes as a system for evaluation of X-ray effects, it can be assumed that if any enzyme among the group of interdependent reactions is inhibited there will be an accumulation of substrate and a change in the yield of phosphate esters. Complex multiple enzyme systems, such as are involved in erythrocyte metabolism of nucleosides, have certain disadvantages as well as advantages in studies of radiation effects. The disadvantage in such systems is that it may be difficult to determine which particular enzyme was affected by the radiation. However, the advantage in using a multiple enzyme system is that this increases the opportunity of finding one or more enzymes sensitive to absorbed radiation.

Erythrocyte Turnover

In the studies on the enzymic changes at prolonged post-irradiation intervals, time of residence of the circulating erythrocyte is a major factor for consideration. This requires that the maximum post-irradiation time-interval used for evaluation must be within the period when the irradiated erythrocyte population is not markedly altered. This can be calculated from the erythrocyte life-span.

Inbred strains of rats are convenient for radiological studies. The 'mean life-span' of rat erythrocytes as well as the 'half-clearance time' can be used to estimate changes in erythrocyte population. The 'mean life-span' of an erythrocyte is the average interval of time any erythrocytes will remain in circulation; 'half-clearance time' is that time-interval at which 50 per cent of the circulating erythrocytes will disappear from circulation. Belcher and Harriss[4] have recently reported the 'mean life-span' of the rat erythrocyte as 49–55 days. The 'half-clearance time' was determined as $20{\cdot}7 \pm 2{\cdot}5$ days.

Since these observations are based on the mean life-span and half-clearance time of erythrocytes in the normal rats, it is important to know how these figures are altered in X-irradiated rats. Total-body X-irradiation of rats in excess of 300 r. causes complete inactivation of marrow and stops the extrusion of erythrocytes into circulation[10]. However, the life-span and half-clearance time of the circulating erythrocytes remain relatively the same as in the unirradiated animals[11]. There is evidence that random (non-senescent) destruction of erythrocytes, which in the normal rat is approximately 0·48 per cent per day[5,6], is increased in the irradiated animals but the magnitude of this change is unknown[11].

Recognizing the prolonged inactivation of marrow after an X-ray dose of 300 r. or higher, we see that the erythrocyte population will consist only of irradiated cells up to and even beyond a two-week period, since no new cells are extruded by marrow during this time. However, due to internal hæmorrhages and other undefined factors, random non-senescent loss of erythrocytes will be increased[11]. This will cause a drop in the number of red cells; however, loss of plasma into tissue and dehydration due to vomiting and diarrhœa will tend to decrease plasma volume, hence there may be no net change in hæmatocrit values[11].

The above discussion can be summarized by the conclusion that following total-body radiation with doses at and above 300 r. the erythrocyte population remains relatively undiluted and the life-span and half-clearance time remain approximately the same as in the unirradiated rat, with the exception that there is an increased random loss of erythrocytes which cannot be quantitatively evaluated at present.

It is tentatively concluded that the erythrocyte is a promising tissue component as an internal mammalian X-ray indicator, since: (*a*) it has a wide variety of enzymes among which some may be sensitive to radiation; (*b*) it cannot replace altered enzyme-proteins; (*c*) it has a long life-span even in irradiated animals; (*d*) it is accessible for repeated sampling.

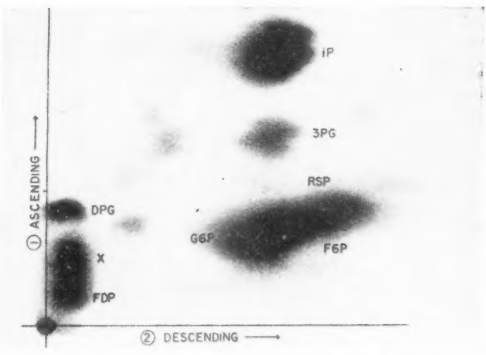

Fig. 2. Radioautogram of phosphate esters separated by two-dimensional paper chromatography, (1) ascending with ethyl-acetate, acetic acid and water (3 : 3 : 1) and (2) descending with methyl ethyl ketone, methyl cellosolve, ammonia and water (7 : 2 : 0·7 : 2·3). *iP*, inorganic phosphate; *3PG*, 3-phosphoglycerate; *R5P*, ribose-5-phosphate; *G6P*, glucose-6-phosphate; *DPG*, 2,3-diphosphoglycerate; *X*, unidentified ester; *FDP*, fructose diphosphate

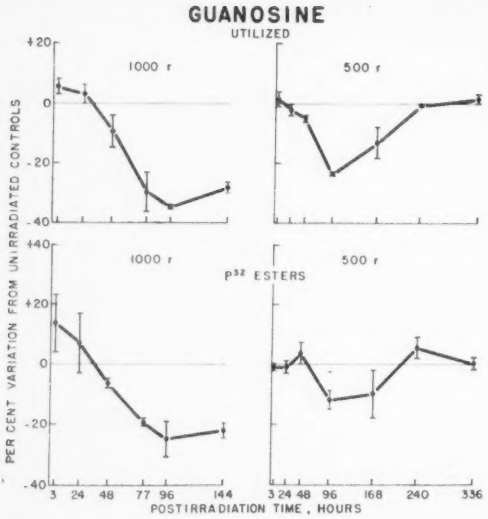

Fig. 3. Comparative utilization of guanosine and formation of phosphate esters by rat erythrocyte extracts from rats irradiated with 1,000 and 500 r. X-rays, respectively

The concepts discussed above were tested by measuring the changes in nucleoside metabolism by erythrocyte extracts from irradiated and unirradiated rats. Our results established that following 1,000 r. whole-body X-irradiation the utilization of purine nucleosides was markedly depressed up to 144 hr. after irradiation. Whole-body irradiation of 500 r. also depressed purine nucleoside metabolism for a period of 96 hr., when the metabolism began to increase and by 240 hr. reached the level of substrate utilization by erythrocyte extracts from unirradiated controls. These results establish that erythrocyte enzymes are affected by moderate whole-body radiation and that these changes are detectable over a period from one to two weeks after irradiation.

Experimental Results

Erythrocytes from irradiated and unirradiated Sprague–Dawley rats were separated from white cells and plasma, lysed in water, dialysed overnight; extracts were then prepared by centrifugation. These extracts were incubated for 2 hr. in *tris* buffer at *p*H 7·4 with either guanosine, inosine, or adenosine in the presence of inorganic phosphate labelled with phosphorus-32 and magnesium chloride. The detailed procedures and techniques will be described elsewhere[12]. After incubation, the remaining purine nucleoside was analysed, total organic phosphate was determined, and the nature of the individual phosphate esters formed was established by means of paper chromatography[13].

The reactions studied in these incubations are represented schematically in Fig. 1 and the phosphate esters actually formed from guanosine and labelled inorganic phosphate are shown by the radioautogram in Fig. 2. The same phosphate esters were also obtained from incubations of inosine and adenosine. Enzyme activity of erythrocyte extracts from rats irradiated with 1,000 r. or 500 r. to the whole body were compared with extracts from unirradiated controls. A decrease in substrate utilization and phosphate ester formation was observed. The results of these experiments are illustrated in Figs. 3, 4 and 5.

Erythrocyte extracts from rats treated with 1,000 r. showed enhanced utilization of guanosine up to 24 hr. after irradiation (Fig. 3); but afterwards both guanosine utilization and phosphate ester formation decreased and at 96 hr. reached a minimum value and remained at this level until the death of the animals in 7–8 days. Extracts from the rats treated with 500 r. showed a decrease in guanosine utilization in 24 hr. after irradiation and this reduced enzyme activity continued until the ninety-sixth hour (Fig. 3; these are similar to the results with the 1,000 r. extracts). Afterwards, the utilization of guanosine increased again and in 240 hr. the level of substrate utilization was equal to that of the controls. Almost identical results were obtained with inosine, as shown in Fig. 4. However, utilization of inosine by erythrocyte extracts from 500 r. treated rats did not reach the level of inosine utilization by the controls until 336 hr. after irradiation. Experiments with adenosine utilization showed results similar to those of inosine.

Significance of Results

These experiments establish that erythrocyte enzymes are affected by lethal (1,000 r.) and sub-lethal (500 r.) whole-body X-irradiation. Also the inhibitory effect of radiation persists for seven days or longer depending on the X-ray dose. Since the same enzymes are involved in the metabolism of guanosine, inosine or adenosine, one would expect radiation to influence these reactions in a similar way, as they did (Figs. 3, 4 and 5).

Although nucleoside metabolism by the erythrocyte extracts from rats treated with 1,000 r. was inhibited during their survival (7–8 days), the extracts from the rats treated with 500 r. X-rays showed a marked inhibition for the initial interval up to 7 days after radiation. This was followed by the recovery of enzyme activity by 7–10 or 14 days post-irradiation. This recovery of activity suggests that with 500 r. whole-body radiation the inhibition was not due to

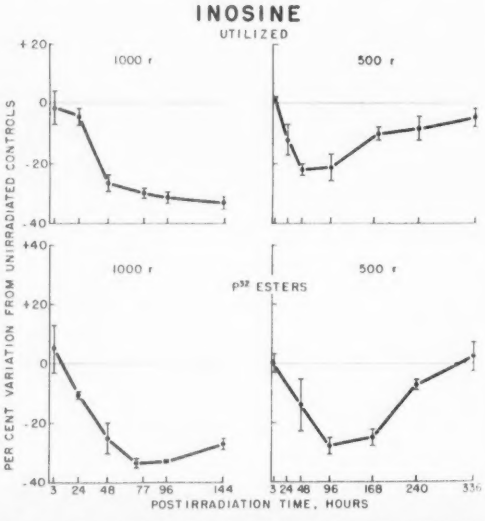

Fig. 4. Comparative utilization of inosine by rat erythrocyte extracts

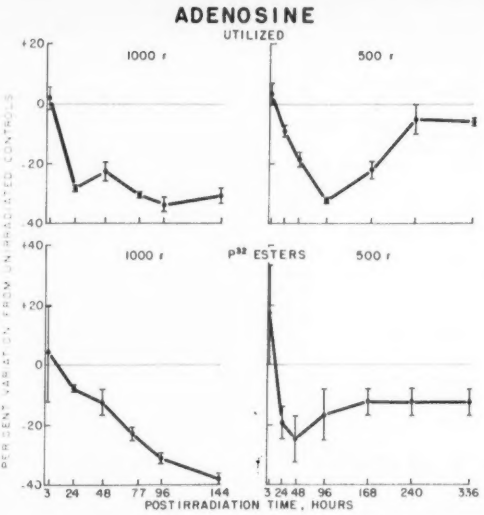

Fig. 5. Comparative utilization of adenosine by rat erythrocyte extracts

irreversible protein damage, but probably to the oxidation of some essential sulphydryl groups to disulphides. Since the erythrocytes contain glutathione, it is likely that the disulphide groups were gradually reduced by the glutathione during the period of recovery of enzyme activity.

Although the radiation does affect the erythrocyte metabolism, how useful is this information in evaluating erythrocyte metabolism as a biological radiation indicator? Data from Figs. 3, 4 and 5 also show that the degree of inhibition, particularly for guanosine and inosine metabolism (Figs. 3 and 4), is appreciably greater at 48 hr. after 1,000 r. irradiation than after 500 r. treatment. Adenosine metabolism decreased in 24 hr. to a greater extent in the rats treated with 1,000 r. than in those receiving 500 r. The variations in erythrocyte activity described above following 1,000 r. and 500 r. irradiation are only the initial observations. Additional data will be necessary to establish the relationship between whole-body radiation dose and degree of enzyme inhibition in erythrocyte extracts. The present results suggest that the metabolism of nucleosides following radiation can serve as a gross biological indicator. This information may encourage other investigators to examine the erythrocyte metabolism in other species, particularly cancer patients requiring total-body radiation treatment, in order to ascertain whether X-ray induced inhibition of rat erythrocyte metabolism also occurs in other animals, as well as in man.

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THE CHEMISTRY OF CLOTHING*

EVEN though clothing is one of the essential needs of human beings, it is only some fifty years since chemists and physicists, in their professional capacity, first began to give any serious thought to the subject, or even to the textile fabrics from which most clothes are made. Almost everyone is, of course, interested in the aesthetics of clothing, and the fashion and style of garments often reflect the spirit of the times. In the past half-century, however, quite outstanding progress has been made, not only in providing new materials for garments, but also in understanding more precisely what is required of clothing to be worn under various climatic conditions. It was fitting, therefore, that at the York meeting of the British Association one session of Section B (Chemistry) was devoted to a symposium entitled "The Chemistry of Clothing".

* Based on the following four papers presented at the York meeting of the British Association for the Advancement of Science:
"Physical Aspects of Clothing for Comfort", by Mr. W. H. Rees (British Cotton Industry Research Association).
"The Chemical Treatment of Apparel Fabrics", by Prof. C. S. Whewell (professor of textile technology, University of Leeds).
"Recent Advances in the Application of Cellulosic Man-Made Fibres to Clothing", by Dr. H. A. Thomas (Messrs. Courtaulds, Ltd.).
"The Use of Synthetic Hydrophobic Fibres in Clothing", by Mr. A. B. Thompson (Messrs. Imperial Chemical Industries, Ltd., Fibres Division).

The scope of the symposium was rather wider than its title implied, for much of the work which has been carried out is more accurately described as applied physics. The principles on which the comfort and usefulness of clothing are based were discussed by Mr. W. H. Rees of the British Cotton Industry Research Association. He pointed out that in cold climates clothing acts as an insulator, thereby reducing heat lost from the body to a level which can be counterbalanced by body metabolism. Since textile fibres are better conductors than air, the greater the amount of air entrapped by a fabric the more effective will it be as an insulator. Rees indicated that only about 6 per cent of the volume of a blanket is occupied by fibres, the remainder being air. In more compact structures this volume of air is reduced, but in most apparel fabrics it is of the order of two-thirds. It is important that the entrapped air should be undisturbed and, consequently, apparel fabrics for use in windy weather should be constructed so that the wind is kept out. Again, if the air in the fabric is replaced by water, as in heavy rain, the efficiency of the fabric as an insulator will fall. According to Rees, therefore, clothing to be worn in wet, windy conditions should comprise "a windproof, waterproof

and vapour permeable outer garment and an ample supply of inner garments having a large air content".

Body heat is also lost by radiation in the far infra-red region. All textiles, whatever their colour, are virtually black bodies, with high emissivities, at least ten times as great as that of a metallic surface. To minimize radiation losses garments have, therefore, been lined with aluminium foil. The heat loss is markedly reduced, but if the layer of foil is continuous, the fabric becomes harsh and unsatisfactory and is impermeable to water vapour. By an ingenious method of perforating the film, however, it has been possible to produce in the laboratories of the British Cotton Industry Research Association a fabric which has the usual textile properties but which is extremely effective in cutting down losses by radiation.

In hot climates clothing must reflect away solar radiation and assist in keeping the body cool by the evaporation of sweat. Reflexion of radiation is clearly determined partly by the colour of the fabric, lighter coloured materials being the more effective. A white fabric will reflect away two-thirds of the incident radiation and a black one only about one-tenth. Mr. Rees has also examined the reflecting power of cotton fabrics dyed the same colour but with different types of dyes, and has found considerable differences in the infra-red. This indicates that although the reflecting power for radiations in the visible region are the same for all the fabrics, those in the infra-red are different. The chemical constitution of the dye is, therefore, important in determining the reflecting power of dyed fabrics. As would be expected, fabrics coated with aluminium foil are excellent reflectors, and if they are produced by the British Cotton Industry Research Association technique their textile properties are not impaired. In addition to being good reflectors, hot weather garments should also assist in the evaporation of sweat, and those worn next to the skin should, therefore, be absorbent and of open structure.

Modern clothing must have many characteristics other than that of being comfortable to wear. It must be æsthetically satisfying and must often have specific properties such as being fireproof, lustrous, mothproof or waterproof. In addition it must retain its appearance and essential properties during wear and after being washed or dry-cleaned. The necessity for garments to retain their essential properties throughout their life is becoming increasingly important and was stressed several times during the symposium.

Although some garments are made from skins, leather, felt and plastics, most are made from knitted, woven or bonded textiles. Fabrics available to the clothing manufacturer may contain both natural and man-made fibres. Garment manufacturing has been, however, largely based on natural fibre fabrics, but with the advent of man-made fibres, the resources of the clothing designer have been greatly increased, for there is an ever-growing production of new fibres and fabrics with interesting and novel characteristics. It was clearly not possible to discuss in the symposium new developments in all types of synthetic fibres and attention was concentrated upon specific fibre types. It must be stressed, however, that progress in the production of other fibres, for example, the acrylics, the polyolefines, and those based on fully acetylated cellulose, has been equally rapid. The development of man-made fibres has made possible the production of fabrics and garments with performance characteristics formerly considered to be unattainable. Of particular importance has been the production of fabrics which are light in weight but yet are strong and durable, and of fabrics which are easily washed and do not require ironing to restore their attractive appearance. These developments have, of course, stimulated research in the treatment and modification of fabrics made from natural fibres so that these materials also can be given some of the attractive characteristics of fabrics made from the newer fibres.

The man-made fibres can be divided into two groups—those which absorb considerable amounts of moisture, for example, viscose rayon, and those which do not, such as 'Terylene' and nylon.

Older forms of viscose rayon had several defects but now a wide range of improved regenerated cellulose fibres can be obtained. It is well known that fibres made by the viscose process have a 'skin and core' structure. The ratio between the amounts of skin and core may, however, be altered by controlling the conditions of xanthation and coagulation, and other desirable properties can be given to the filaments by stretching them immediately after they have been formed. Some of the newer products obtained by such techniques have extremely interesting properties. For example, fibres composed entirely of 'skin' are exceptionally tough and resistant to abrasion wet or dry, being stronger than cotton when wet. Filaments which are all core are obtained by spinning into a solution of ammonium sulphate and stretching the filaments by 50–100 per cent. These filaments are characterized by high strength and low extensibility when wet and are useful for making fabrics which do not shrink or stretch when they are washed. Moreover, by adjusting the spinning conditions so that one side of the fibre has a thick skin and the other a thin skin, asymmetric fibres are obtained. Because of the different swelling properties of the two sides, these fibres are crimped, and even if the crimp is pulled out during processing it will reappear on afterwards wetting the fibre. Provided that appropriate stable pigments can be ground sufficiently finely to prevent blocking the holes in the spinnerets, 'spun dyed' fibres can be produced by almost any spinning process by incorporating the pigment in the dope before it is extruded. The spun-dyed viscose rayons have been found to have some unexpected properties, for not only are the colours very fast to repeated washing and to exposure to bright sunlight, but the dispersed pigments also protect the fibre from photodegradation and deterioration in industrial atmospheres.

The introduction of the hydrophobic apparel fibres was a great step forward in textile science and technology. As Mr. A. B. Thompson pointed out, a good textile fibre must be soft without being too extensible, that is to say, it must be intermediate between a glass and a rubber. It must be elastic rather than plastic, although a plastic state is needed to ensure a satisfactory response to ironing and pressing which are essential in garment making, and often for the subsequent care of apparel fabrics. Natural fibres meet the latter requirements because they can be made plastic by application of heat and moisture. The hydrophobic fibres are much less affected by moisture and consequently retain their elasticity during use, and to achieve the plastic state heat is necessary. In general, therefore, the elastic state required in use and the plastic state needed for

ironing, etc., are quite distinct. This separation of the semi-flexible elastic state required in use from the more flexible plastic state needed for shaping and pressing enables garments made from the hydrophobic fibres to retain their smart appearance during wear and to be pressed or creased permanently when required.

Each natural or man-made fibre has its own characteristics. Many apparel fabrics are therefore made from blends of different fibres, the blend being selected so that advantage is taken of the desirable properties of each of the components. Of particular significance is the blending of hydrophobic and hydrophilic fibres to produce fabrics which are light, durable, and easily cared-for, but yet comfortable to wear.

Almost all fabrics are improved by suitable chemical treatment. The changes brought about must, however, be 'permanent'. Processes of this type were discussed by Prof. C. S. Whewell, emphasis being laid on developments in the production of crease-resistant, 'drip-dry' and 'minimum-care' fabrics, the permanent pleating of wool fabrics, methods for obtaining textile fabrics which do not shrink or expand when they are washed, and the production of fabrics which are permanently mothproof, fireproof and waterproof.

The four papers presented at the symposium formed a useful indication of some of the important trends in the production of better apparel fabrics and garments. The craft of the tailor and the cloth designer is now being supplemented by the skill and resources of the scientist. This combined approach to the problems associated with clothing is comparatively new, but the success which has so far been achieved is ample proof of the value of the collaboration. The opportunities for research and development in this field are indeed exciting. Perhaps a future meeting of the British Association will be the occasion on which the results and achievements will be discussed.

C. S. Whewell

RESEARCH IN THE ANTARCTIC DURING 1960

British Programme

THE Falkland Islands Dependencies Survey maintains a number of permanent scientific stations within the Falkland Islands Dependencies sector of the Antarctic. Many of these have been in continuous occupation since 1944. During the International Geophysical Year they played their part with the stations of other nations in the general co-ordinated plan. At the end of 1958, the Royal Society station at Halley Bay was handed over to the Survey and will continue to work like that of the other stations of the Falkland Islands Dependencies Survey, into the indefinite future.

The main geophysical stations are at the Argentine Islands and Halley Bay, the two being separated by about 1,000 miles. At both, daily upper-air soundings will continue, as will the surface meteorological work which is common to all bases except Port Lockroy. Fluxplates and solarimeters will be in use for the study of radiation balance, and both stations will continue ozone observations using the Dobson spectrophotometer.

The ionospheric work at Port Lockroy, only 40 miles from the Argentine Islands, will continue in operation, as will the recording of whistlers which forms a part of the programme initiated from Dartmouth College, New Hampshire.

At Halley Bay the ionospheric equipment was not in use last year but is to be brought into commission again for 1960. On the other hand, it has been decided to abandon the seismological work there, but to continue using the Willmore short-period seismographs at the Argentine Islands.

Because of the geomagnetic latitudes of the stations of the Falkland Islands Dependencies Survey, very few auroral displays are observed except at Halley Bay. There an all-sky camera will continue in operation, and other studies include a small glaciological programme, observations of sea ice growth and of the measurements of marine currents.

In the coming year an attempt will be made to recover cosmic spherules falling on the ice sheet, and also to obtain samples from deep within the ice. Since there can be no dilution by other sedimentary materials, it may prove possible to determine a rate of deposition for this cosmic material.

The other bases extend from South Georgia, where there is a purely meteorological station, through the South Orkneys and the South Shetlands along the coast of Graham Land to about lat. 68° S. All are manned throughout the year, the number of men varying between five and eighteen. During the summer, work is to be carried out from the ships operating in the area. These will be R.R.S. *John Biscoe*, R.R.S. *Shackleton*, H.M.S. *Protector* and the Danish vessel *Kista Dan*, chartered for the season.

John Biscoe will be committed almost entirely to relief and re-storing the bases, but it is hoped to operate a wave-recorder on board to investigate the damping effect of pack ice. This is not only of academic interest, but will also be valuable when forecasting the break-up of the sea ice. All bases maintain constant sea ice observations which already provide a background upon which seasonal probability charts are being built up. If the protective effect of large areas of drifting pack can be assessed, ice forecasts for shipping will be materially assisted.

Shackleton will be extending hydrographic surveys along the west coast of Graham Land and around the South Shetland Islands. In addition, she has been fitted to tow a proton resonance magnetometer so that investigation of the Scotia Arc can be begun. This work will tie up with the magnetic traverses already in progress from Hope Bay in the Trinity Peninsula area. A Worden gravimeter will also be carried and put ashore for gravity observations at as many points as possible.

H.M.S. *Protector* carries helicopters and these will be used to extend the tellurometer survey where the landing of men and instruments cannot be made in any other way.

The task of the *Kista Dan* is to re-establish the southernmost base on Stonington Island, which had to be evacuated last year because of bad ice con-

ditions. She will be carrying two aircraft which can be used for the transport of men and material, but if the ship is held up by bad ice conditions their first task will be to re-supply the base. Then reconnaissance flights are to be made southward to select a site for a field hut which will be flown in at the end of the season. Both aircraft will winter at the base and can therefore support field parties making topographical and geological surveys in the remoter regions during the early part of the 1960–61 season. The *Beaver* aircraft is fitted with a Williamson vertical camera so that photographic cover can be obtained over the more inaccessible areas.

Geological and topographic surveys will also continue from a number of other stations and, in addition to the glaciological programme at Halley Bay, glaciologists will be working from Hope Bay, Admiralty Bay and King George Island.

In the coming year biological work will have less emphasis than in some years, but the marking and population counts of fur seals and elephant seals will continue. A small project concerned with soil ecology is to begin at Signy Island. Also at Halley Bay, where there is a rookery of 10,000 emperor penguins, a biologist has been appointed to continue the study of the species. In particular, an examination of the endocrinology of the bird and a further collection of embryological material will be made.

In each southern summer, ice conditions are different, and it is this which often hinders the planned programme. Last year was a bad year; this year we hope for better things, but in any event it is certain that the only way to succeed is to keep up the pressure and be ready to take advantage of any relaxation which Nature may afford.

Vivian Fuchs

American Programme

A statement released by the National Science Foundation gives details of grants for scientific investigations either in or associated with Antarctic regions. Logistic support will again be the responsibility of a U.S. Navy support force under Rear Admiral David M. Tyree, who has recently taken over from Rear Admiral George J. Dufek. The grants total 3,170,069 dollars, of which approximately one-third goes to support the meteorological programme and one-quarter to glaciological projects. Greater emphasis than formerly is placed on geology, cartography and biology, which is in accord with the recommendations of the Special Committee on Antarctic Research of the International Council of Scientific Unions.

Among new projects mentioned are a United States scientific expedition to the Bellinghausen Sea which will include specialists in biology, geology, cartography and oceanography.

The International Geophysical Year pattern of over-snow traverse operations will be continued in Marie Byrd Land and Victoria Land. Biological investigations on the ecology of the Ross Sea area and on land invertebrates of the McMurdo Sound and Hallett areas will be helped by the recently established U.S. Antarctic Biological Research Laboratory at McMurdo.

The investigations will be spread over seven Antarctic stations of which three are fully and one jointly under the direction of the United States. Co-operation with other countries in these investigations in both scientific and logistic spheres has been a notable feature of the U.S. Antarctic effort, and this appears likely to continue.

NEWS and VIEWS

The Third Russian Space Rocket

A multi-stage space rocket was launched in the U.S.S.R. at about 02h. u.t. on October 4. When the last stage, weighing 1,553 kgm. (3,424 lb.) without fuel, had reached a speed slightly less than escape speed from the Earth, an instrumented vehicle weighing 278·5 kgm. (614 lb.) separated from it. This vehicle entered an elongated elliptic orbit which took it into the vicinity of the Moon. Its nearest approach to the Moon occurred at 14h. 16m. u.t. on October 6, when it was about 7,000 km. (4,300 miles) from the surface of the Moon, at selenographic longitude 137° W. and latitude 12° S. After leaving the vicinity of the Moon, the vehicle entered a new elliptic orbit about the Earth, with an apogee distance of 470,000 km. (292,000 miles) from the surface of the Earth, attained at about 00h. u.t. on October 11, and a perigee distance of 40,000 km. (25,000 miles), attained at about 17h. u.t. on October 18. The orbit is inclined at about 75° to the Earth's equator and the period of revolution is about 15·4 days. The vehicle has been designated Earth-satellite 1959 0. The orbit of the spent rocket is not known. The instrumented vehicle, which the Russians have referred to as an "automatic interplanetary station", carried apparatus to photograph the part of the Moon which is never seen from the Earth, and also apparently performed other scientific experiments, of which details have not yet been given. The vehicle had radio transmitters operating on 39·986 Mc./s. and 183·6 Mc./s., the power being supplied partly by chemical and partly by solar batteries.

Research Association of British Paint, Colour and Varnish Manufacturers: Dr. L. A. Jordan, C.B.E.

Dr. Louis Arnold Jordan, the founder-director of the Research Association of British Paint, Colour and Varnish Manufacturers, has relinquished his appointment after thirty-three years. The Paint Research Station at Teddington, at present being further extended, stands in testimony to his achievement. Educated at Alderman Newton's Greencoat Foundation School, Leicester, he proceeded as a Royal scholar in 1910 to the Royal College of Science, where he was Tyndall prize-man in physics and Frank Hatton prize-man in chemistry. He received the D.Sc. (London) in 1921. During the First World War he was concerned with explosives, and certain 'gas' problems; thence to Boots Pure Drug Co., Ltd., and later to the British Xylonite Co., Ltd., to start an investigation which resulted in the establishment of the British synthetic camphor industry. From 1923 until the establishment of the Paint Research Association in 1926 he was scientific adviser

to the State of Bhopal, Central India. He returned to India in 1955 at the invitation of the Government of India to inquire into matters touching the development of the lac industries. In fact, he is widely travelled (another recent journey having been to Brazil to advise on organized research in paint and related matters) and is well known internationally, for example, through his work for the Organic Coatings Division of the Applied Chemistry Section of the International Union of Pure and Applied Chemistry.

Dr. Jordan has given extensive service to the Oil and Colour Chemists Association (he was president during 1947–49) and to numerous other scientific and technical organizations. He was chairman of the council of the Society of Chemical Industry during 1952–53 and medallist of the Society in 1953. As one of the Jubilee Memorial lecturers of the Society (1944) he chose as his subject "Paint, the Art and Science", reflecting his interest in the artistic as well as in the industrial and scientific aspects of paint and painting, an interest culminating in 1958 in his appointment as professor of chemistry at the Royal Academy of Arts. His work for technical education stands high in achievement and personal satisfaction. He has for long been chairman of the City and Guilds Advisory Committee on Paint Technology, and his period as a Surrey county councillor (1946–58) provided opportunities for contributions in a wider field of technical studies. He is now chairman of the governors of the Kingston Technical College, a governor of the Brunel College of Technology, and a member of the Regional Advisory Council for Technological Education for London and the Home Counties Region. He has recently been appointed to the senate of the University of London.

Botany at Hull : Prof. R. D'O. Good

Prof. Ronald Good, who has retired from the chair of botany in the University of Hull, was head of the Department of Botany from the foundation of the University College in 1928. After serving in the First World War, followed by a brilliant period at Downing College, Cambridge, he held an appointment at the British Museum (Natural History). At Hull he had much to do with the organization and equipment of his department, as well as teaching, but he has also been active as a researcher and writer. His book on the "Geography of the Flowering Plants" has had a wide circulation and is regarded as one of the chief works on the subject, while his "Handbook of the Dorset Flora" is an outstanding ecological study.

Prof. N. F. Robertson

Dr. N. F. Robertson, who has succeeded Prof. Good, has been on the staff of the Cambridge Botany School since 1948. His interest in mycology was first aroused by Dr. Malcolm Wilson at the University of Edinburgh. After graduating there in 1944, Dr. Robertson was appointed a Colonial Office probationer and studied at the University of Cambridge, at Rothamsted Experimental Station and in the United States before proceeding to the West African Cacao Research Institute at Tafo late in 1946. He worked there, in collaboration with Dr. A. F. Posnette, on insect transmission of the swollen shoot disease. Dr. Robertson's first research problem at Cambridge was concerned with mycorrhizal infection of the Scots pine, and he made a notable contribution to the subject by showing that the behaviour of the mycorrhizal fungus was closely related to that of the specialized root disease fungi affecting tree crops. More recently, Dr. Robertson has turned his attention to the physiology of fungal branch systems in culture, and has made what may eventually prove to be the first experimental approach to the morphogenesis of asexual spore production. With his research students, Dr. Robertson has explored a much wider field, ranging from the physiology and genetics of the Fusaria in laboratory experiments to the behaviour of Fusarium wilt diseases and potato blight in the field. The University of Hull is doubly fortunate in securing Dr. Robertson as professor of botany, because he has distinguished himself at Cambridge not only by his research but also as a teacher, and by the full share he has taken in other duties in the Department of Botany, where he will be greatly missed.

The World Veterinary Association : Prof. W. I. B. Beveridge

At the recent International Veterinary Congress in Madrid a World Veterinary Association was established. The main purposes of the Association are to unify the veterinary profession throughout the world by providing a central link for national veterinary associations, and the exchange of information on matters of veterinary interest. The organs of the Association are the congress and the permanent committee.

Prof. W. I. B. Beveridge, professor of animal pathology, University of Cambridge, has been elected president of the Permanent Committee of the newly founded World Veterinary Association. He has had a distinguished career as a veterinarian who gave outstanding service to his profession in Australia and in the United Kingdom. After graduating at the University of Sydney, he was a member of the research staff of the McMaster Animal Health Laboratory in Sydney during 1931–41. During two years of that time he was the holder of a Commonwealth Fund Fellowship at the Rockefeller Institute, Princeton, and the Bureau of Animal Industry, Washington. From 1941 until his appointment as professor of animal pathology in Cambridge he worked at the Walter and Eliza Hall Institute in Melbourne. Together with Sir Macfarlane Burnet he worked on viral diseases in man and published several outstanding papers concerning cultivation of viruses. In Cambridge, Prof. Beveridge's researches are mainly concerned with viral diseases of respiratory systems in animals. Unfortunately, his scientific work there was very much interrupted by administrative duties associated with the establishment of the new Veterinary School which was opened by H.M. the Queen and the Duke of Edinburgh in October 1955. He is the author of the book, "The Art of Scientific Investigation". Both on account of his outstanding reputation and his interest in international co-operation, he will be a most welcome president of the newly founded World Veterinary Association.

Amendments to the U.S. Atomic Energy Act

In a report by the United States Atomic Energy Commission (The Indemnification of Atomic Energy Activities and Operations of Advisory Committee on Reactor Safeguards, 1958–59. Report of the Joint Committee on Atomic Energy on Operations under Section 170 of the Atomic Energy Act of 1954 as Amended. Pp. iii+74. Washington, D.C.: United

States Atomic Energy Commission, 1959), details are given of the proposed regulations approving the form of nuclear energy liability insurance policies and Commission indemnity agreements. Amendments to the indemnity proposals of the Atomic Energy Act, 1954, which it is proposed to submit to Congress, exclude liability for damage to property located at the site of, or used in connexion with, the licensed activity, and would authorize the Commission to fill a gap for a sufficient period of time in which to give the licensee reasonable opportunity to furnish the required protection. The Commission is also studying the possible gaps resulting from the 'common occurrence' provision, and has entered into a contract for a study of criticality hazards as part of its continuing study of the problem of extending indemnity to materials licensees. As regards foreign liability problems, the efforts of the Commission have been directed primarily to encouragement and support of the efforts of other governments to enact their own legislation and effect international arrangements.

Scientific Staff in New Zealand

During the past twelve months, six officers of the Ruakura Animal Research Station in New Zealand have resigned to accept posts in Australia. All have received an increase of salary of £A500 to £A1,000 on taking up their new posts. The maxima attached to their new position in Australia is, in all cases, about twice that offered for the positions they vacated in New Zealand. Another 25 individuals have resigned from Government laboratories or science departments of New Zealand universities during the past three years to accept overseas posts, mainly in Australia. This figure does not include graduates in science who have gone overseas for advanced training.

Both Government departments and the universities experience great difficulty in replacing the losses of scientific staff with persons of the desired quality. The Soil Bureau of the Department of Scientific and Industrial Research has been seeking pedologists for some time without success, and advertisements for mycologists, entomologists, mathematicians and physiologists have failed to attract any applicants or applicants of the desired qualifications and calibre. Whereas five years ago there were usually a number of highly qualified applicants for each vacancy from which selection could be made, the position has changed so that to-day only one or two such applicants and sometimes none at all apply for advertised positions.

Scientific Research in British Universities

"Scientific Research in British Universities, 1958–59", based, as in previous years, on material collected by the British Council from heads of departments of the universities, who are alone responsible for the entries, now runs to 446 pages (pp. xii+446. London: H.M. Stationery Office, 1959. 25*s*. net). These brief notes on scientific research in progress during the 1958–59 session indicate the nature of the projects in sufficient detail to show the scope of the research. Entries are arranged in alphabetical order of university or university college, and under each institution the arrangement is alphabetically by subject. The head of the department is named, with those permanent members of staff actually engaged in supervising research. There are alphabetical name and subject indexes.

Registration of Scientific and Technical Persons, 1958

Fresh and renewed registrations for all professional classes covered by the Technical and Scientific Register of the Ministry of Labour, with the exception of mathematicians and physicists, steadily increased during 1958, according to the Ministry's annual report. At the end of December, registrations, including those seeking a change as well as those employed, were 29 per cent higher than in December 1957, a significant part of the increase comprising registrations of men in the middle age groups seeking better positions before age restricted their prospects and from ex-regular members of the Forces who had retired or anticipated premature retirement. At December 8, 1958, of 4,556 on the register, compared with 3,538 in 1957, 1,326 were unemployed. Premature retirements from the Services reached a peak during the year, but the Regular Forces Resettlement Service, set up by the Ministry, received encouraging support from industry and commerce, and there was no significant increase at the end of the year in the number of such applicants unemployed. The report also directs attention to the establishment in July 1958 by the British Employers' Confederation, the Trades Union Congress and the boards of the nationalized industries, of the Industrial Training Council in accordance with the recommendation of the Carr Committee. This Council has undertaken as its first task the encouragement of industry generally to take advantage of the opportunities provided by the 'bulge' of school-leavers to expand apprenticeship schemes and other forms of training. Thirty-two appointments were made to the general factory inspectorate, and with five applicants awaiting appointment, the number of vacancies at the end of the year was nine. Five additional appointments were made to the Engineering and Chemical Branches of the inspectorate. On the advice of the National Advisory Committee on the Employment of Older Men and Women, the Ministry is discussing with the Department of Scientific and Industrial Research and the Medical Research Council arrangements to ensure co-operation between the Ministry, industry and research organizations and to stimulate research into problems of employment of older workers.

Rubber Research

The twenty-second "Annual Report on the Progress of Rubber Technology" covers the progress of rubber technology during the year 1958 (edited by Dr. T. J. Drakeley. Pp. ix+125+xii. Cambridge: W. Heffer and Sons, Ltd., 1959. Published for the Institution of the Rubber Industry). The report contains twenty-three sections, by different contributors, covering all aspects of the technology of rubber-like materials, both natural and synthetic, ranging from surgical goods to the use of rubber in roads. The report also includes sections on historical and economic aspects, planting and production of natural rubber, fibres and fabrics used in conjunction with rubber, compounding ingredients and, for the first time, a separate section on the manufacture of synthetic rubbers. The introduction of this latter section is timely since 1958 saw the opening in Italy, Germany and the United Kingdom of the first major European plants for the production of general-purpose synthetic rubber. Synthetic elastomers are now firmly established as a large and important part of the rubber industry. Already approximately 65 per cent of American new-rubber consumption consists

of synthetics; the corresponding figure for the rest of the world (excluding Communist countries) is 25 per cent, but this is likely to increase with the opening of the new plants. The year does not appear to have produced any outstanding new technical developments but rather a steady improvement of materials and techniques. The report contains more than one thousand references to scientific and technical publications, although, as is inevitable in a work of this kind, there is some overlapping from section to section.

Aerial Photographic Exhibition of Quarries and Mines

A SPECIAL exhibition of aerial photographs of quarries and mines opened at the Geological Museum, Exhibition Road, London, S.W.7, on October 15. Admission is free. The exhibition will remain open for several months. The photographs show past and present surface aspects and effects of quarrying and mining in the United Kingdom, and illustrate the great variety of useful rocks and minerals found in Britain. All the photographs are from the Cambridge University Collection, an extensive library of air photographs specially selected to meet needs of teaching and research. They have been taken during recent years by Dr. J. K. S. St. Joseph, curator in aerial photography at Cambridge, from aircraft of the Royal Air Force on training flights.

Petroleum Industry in Great Britain

THE Petroleum Information Bureau has published under the title "U.K. Petroleum Industry Statistics relating to Consumption and Refinery Production, 1957 and 1958" (Pp. 10. London: Petroleum Information Bureau, 1959) figures covering all petroleum products, whether imported or from indigenous sources, as well as substitutes such as benzole and hydrogenated spirits. Refinery production figures do not count further treatment of finished products for special grades. The figures relate to 1957 and 1958, in which deliveries and consumption of petroleum products totalled 24,784,586 tons and 31,065,629 tons, respectively.

New Journal of Glass Technology

MORE and more problems in the physics and chemistry of glasses are being investigated in laboratories all over the world. At present the results are published in many non-specialized journals and the time has come to provide a vehicle for these papers. The Society of Glass Technology has therefore decided that from February 1960 its *Journal* should be published in two parts. These will be called *Glass Technology* and *Physics and Chemistry of Glasses*. Both journals will contain papers, abstracts, communications to the editor and book reviews. Arrangements are being made with the Abstracting Board of the International Council of Scientific Unions to ensure that papers published in these new journals will be abstracted as widely as possible and also that the abstract sections will be comprehensive. *Glass Technology* will contain reports of applied science in the glass industry, and subjects considered suitable include: control of batch compositions; corrosion of refractories; design, operation and performance of furnaces; methods of chemical and physical testing; melting processes; statistical analysis of industrial experimentation. In *Physics and Chemistry of Glasses* will be published reports of original studies of the physics and chemistry of glasses, both experimental and theoretical. Possible subjects include: electrical properties; infra-red absorption; relaxation processes; thermodynamics of the glassy state; viscosity; X-ray diffraction. Copies of the Society's notes for authors are available from Prof. R. W. Douglas, Society of Glass Technology, Thornton, Hallam Gate Road, Sheffield 10.

Plant Nematology

IT is now recognized that eelworm diseases are among the most important problems in plant health and there has been a rapid increase in the study of plant parasitic nematodes in all countries where the growing of plants has become an organized industry. Unfortunately, there is a shortage of trained specialists in nematology and of introductory literature on the subject. The Ministry of Agriculture's new Technical Bulletin No. 7 (Pp. vii+175+12 plates. London: H.M. Stationery Office, 1959. 9*s*. 6*d*. net) provides a general introduction and is based on the lectures given at a special training course held at the National Agricultural Advisory Service regional headquarters, Bristol, in 1956. It also reviews the more important nematode problems in British agriculture and is in part designed as a companion volume to Technical Bulletin No. 2 (Laboratory Methods for Work with Plant and Soil Nematodes). Although primarily designed for nematologists it should also be of interest to agricultural entomologists, plant pathologists and others who have to advise on eelworm problems and also to students and teachers of zoology, agriculture and parasitology. It contains 21 articles by research and advisory workers, arranged in six main sections covering the general structure and classification of nematodes, the more important genera, several practical and research problems with cyst-forming eelworms, control and cultural studies.

Sea Fisheries Research in East Africa

THE annual report for 1958 of the East African Marine Fisheries Research Organization (pp. 20. Nairobi: Government Printer, 1959. 4*s*.) is one that reflects great credit on the small staff at Zanzibar. Research on the fish and fish-stocks of the Indian Ocean, first at Mauritius and now at Zanzibar, has been the post-war concern of the director, Dr. R. H. Wheeler, and it is good to learn from him that the phase during which it has been of first necessity to identify species is passing. In spite of the need to do systematic work, Dr. Wheeler, operating from Mauritius with a small converted fishing vessel, had already discovered a large and potentially rewarding line fishery in the neighbourhood of Seychelles Banks. The same vessel was transferred to Zanzibar, but during 1957 it was replaced by a large and more serviceable trawler, the *Manihine*. Among other tasks assigned to *Manihine* was floating long-line fishing for yellow-fin tuna and striped marlin. Using seven miles of line and two hundred and fifty hooks on or below the thermocline at 50–70 fathoms, heavy catches were made. These results are most encouraging for all those who wish to see the Colonies, Dependencies and emerging Commonwealth countries of Africa break into the oceanic resources of pelagic fish now so largely in the hands of the Japanese.

Translocation of Amino-Acids

THE translocation of carbon-14-labelled amino-acids and amides in the stems of young soyabean

plants has been investigated by C. D. Nelson and P. R. Gorham (*Canadian J. Bot.*, **37**, 3, 431 (1959)) with the following results. In all, the translocation of each of seven amino-acids and three amides was measured for periods of 5 minutes or less after introduction through the cut petiole of a primary leaf. The compounds used were asparagine, urea, glutamic acid, glutamine, glycine, norleucine, arginine, serine, alanine and aspartic acid. During the short times of these experiments it was found that each compound was translocated downwards as such. The amount of carbon-14 in the stem decreased logarithmically from the point of introduction. Each compound was translocated with unchanged velocity past a short section of stem killed with steam. There was no translocation of aspartic acid through a stem that had an entire internode killed with steam. Potassium cyanide (10^{-2} *M*) did not inhibit the velocity of translocation of any of the compounds although the logarithmic pattern of distribution of arginine was altered. The minimum velocity of translocation was different for each compound and varied between 350 cm. per hr. for asparagine and 1400 cm. per hr. for aspartic acid. The authors have also reported on the physiological control of the distribution of these substances (*Canadian J. Bot.*, **37**, 3, 439 (1959)). From the point of introduction, translocation of each amino-acid or amide was mainly downward towards the root; very little was translocated upward. Both excision of the roots and chilling decreased the velocity of downward translocation of aspartic acid, indicating that the roots exert a strong 'demand' which favours translocation in a downward direction more than an upward direction in the stem.

Volcanic Activity on the Moon

In a brief article, N. A. Kozyrev (*Priroda*, **3**, 84; 1959) describes his observations of the Moon since 1955 and provides a critical examination of the records of the Alphonse crater on November 3, 1958. In his opinion the spectrographic evidence suggests strongly that an eruption of volcanic ash did take place on that date on the Moon. This eruption was followed by the emission of gases containing C_2 molecules.

Astronomische Gesellschaft Star Catalogues

Between 1868 and 1908 the Astronomische Gesellschaft organized the production of a catalogue of all the stars brighter than the ninth magnitude in the northern sky. A dozen observatories shared in this work, the observations being made visually using meridian circles. It was later decided to repeat the whole programme photographically, and new observations were obtained during the years 1928–32. The Hamburg Observatory photographed the sky north of +20° declination, the Bonn Observatory that from +20° to −2°. Observations of 14,000 reference stars were made at several observatories. The measurement of the photographs and the reduction of the measures have been in progress since 1932, and publication of the results began in 1951. The results are contained in a fifteen-volume catalogue, and the last five volumes of this catalogue have recently been published. The catalogue contains the positions of 180,000 stars down to magnitude 11·5. No proper motions for the stars were deduced because it was impossible to free the earlier catalogues from systematic errors. The homogeneity of the results of this large undertaking represents one of its most important features, and the catalogue is, and will remain, a landmark in positional astronomy. The catalogue is known as the *AGK2*.

It has been decided to repeat the whole catalogue with a mean epoch of about 1960. 18,000 secondary reference stars are being observed at various observatories; the photography is being performed at Hamburg and 1,939 plates will be required. It is hoped to have positions and proper motions for all the 180,000 stars by 1965. This new catalogue, the *AGK3*, will enable astronomers to determine the systematic errors of old catalogues, connect the proper motions of the bright stars with those of fainter stars measured relative to the extragalactic nebulæ, and provide much data for geodetic purposes.

Courses in Chemical Engineering

A new pamphlet, "Scheme for a Full-time Course in Chemical Engineering" (pp. 16. London: Institution of Chemical Engineers, 1959. 2*s*.), is a revised version of the "Scheme for a Degree Course in Chemical Engineering", originally issued in 1944, and takes account of current developments in teaching chemical engineering at technical colleges. The course covers three years, and although in the first two years most of the time is spent on physical, organic and inorganic chemistry, the physics of solids, electricity, and mathematics, fluid mechanics, heat and mass transfer, the design and construction of process plant, power thermodynamics and engineering drawing are introduced at this stage and not left until the final year. In this year the course comprises fluid and particle mechanics, heat and mass transfer, separation processes, applied chemical thermodynamics and kinetics, fuels and combustion and design problems. Practical experience in works is regarded as an essential adjunct to the course, and the economic aspect should be introduced into lectures on chemical process principles in the first year. The course should not be so rigid as to preclude transfer to chemical engineering in the earlier years by students who have commenced studies in a cognate faculty.

Talanta Medal

The board of editors of *Talanta* announces a new award to be known as the Talanta Medal. The publishers, Pergamon Press, are providing the funds for this Medal, which will have a value of 100 guineas and which will be awarded for outstanding contributions to analytical chemistry. The Medal will not normally be awarded more frequently than once a year, but no attempt will be made to award it at any stated intervals. This award will be either to analytical chemists who are responsible for major developments in the subject or to scientists whose work is judged to have contributed in a substantial way to the developments in the field of analytical chemistry. Applications should be sent to the editors of *Talanta*, c/o Pergamon Press, 4–5 Fitzroy Square, London, W.1.

Perkin Centenary Trust

The programme of awards for the year 1960–61 will include one Perkin Centenary Fellowship, valued at not less than £600 a year, which is available to a graduate for advanced studies, and two Perkin Centenary Scholarships at £300 a year, which are intended to give young persons employed in the industries concerned with the manufacture or the application of colouring matters the opportunity of full-time education at a university or technical

college. Applications are invited for the Perkin Trust Travel Grants from teachers concerned in the study of any aspects of the manufacture or applications of colouring matters at a university or technical college or other institute. The purpose of the grants is to enable teachers to make short visits to comparable institutions overseas to widen their experience. The secretary to the trustees is Dr. J. R. Ruck Keene, to whom inquiries relating to awards should be addressed, at the Chemical Society, Burlington House, London, W.1.

Harkness Fellowships of the Commonwealth Fund

THE awards bearing since 1925 the title Commonwealth Fund Fellowships were renamed in 1959 the Harkness Fellowships of the Commonwealth Fund. All Fellowships are tenable in the United States and are offered, in separate series, to candidates from the United Kingdom, Australia and New Zealand, and Western Europe. The Fund, an American philanthropic foundation, believes that international understanding may be promoted by opportunities for education and travel in the United States. Thirty Fellowships are offered in 1960 to candidates from the United Kingdom who are British subjects and are either graduates or have experience in government service, the professions, the creative arts, journalism, branches of business or industry. Forms of application, which must be returned before December 1, can be obtained from the Warden, Harkness House, 38 Upper Brook Street, London, W.1, from whom further details can be obtained.

British Institution of Radio Engineers: Awards

THE Council of the British Institution of Radio Engineers has announced the award of a number of premiums for outstanding papers published in the Institution's *Journal* during 1958: the senior award, the Clerk Maxwell Premium, goes to Mr. C. Powell and Mr. D. A. Hendley (Decca Navigator Co., Ltd.) for the paper, "Dectra: A Long Range Radio Navigation Aid"; Heinrich Hertz Premium to Mr. K. Foster (Cossor Radar and Electronics, Ltd.) for the paper, "The Characteristic Impedance and Phase Velocity of High-Q Triplate Line"; for the third successive year the Sir Louis Sterling Premium to Dr. A. van Weel (Philips, Eindhoven) for his paper, "Design of Detector Stages for Signals with Symmetrical or Asymmetrical Side-bands"; Sir J. C. Bose Premium to Dr. B. Ramachandra Rao, Dr. M. Srirama Rao and Mr. C. Abhirama Reddy, from Andhra University, South India, for their paper entitled "Magneto-ionic Fading in Pulsed Radio Waves reflected at Vertical Incidence from the Ionosphere"; Brabazon Premium to Prof. D. G. Tucker, Dr. V. G. Welsby, Mr. R. Kendall and Mr. D. E. N. Davies for their associated papers entitled "Electronic Sector Scanning" and "Radar Systems with Electronic Sector Scanning"; and Marconi Premium to Dr. Morton B. Prince and Mr. M. Wolf, of Hoffman Electronics, Inc., Evanston, Illinois, U.S.A., for their paper "New Developments in Silicon Photo-voltaic Devices".

Volume Fifty of the "Large Soviet Encyclopædia" ("Bolshaya Sovietskaya Enziclopediya")

THIS volume, part of a set of fifty, could not be sold separately when it was originally issued. In 1957, however, a special edition of 300,000 copies was printed, which could be sold separately. Thus this finely printed and bound volume of 764 pages can be purchased in Britain for the sum of £2. It contains summary articles or reviews of all aspects of the Soviet Union and thus it is an invaluable reference book for anyone interested in this subject. It is illustrated by a large number of folding and text maps, plates, text figures and tables. Scientific workers will be interested in the following chapters: 3, geography, geology, climate, soils, vegetable and animal worlds of the Soviet Union; 4, population; 5, history; 9, economics; 12, education; 15, science. Chapters which follow deal with literature, arts and other subjects. Chronological tables and a name index are placed at the end.

Announcements

DR. A. J. P. MARTIN, of Elstree, Herts, Dr. R. L. M. Synge, of the Rowett Research Institute, Bucksburn, Aberdeenshire, and Dr. A. T. James, of the National Institute for Medical Research, Mill Hill, have been awarded John Price Wetherill medals of the Franklin Institute for their development of gas–liquid (partition) chromatography.

AT the sixth annual general meeting of the Association of Clinical Biochemists, held at the Royal College of Surgeons, London, on October 3, the following officers were elected: *President*, Dr. C. P. Stewart; *Chairman*, Dr. A. L. Latner; *Hon. Treasurer*, Dr. J. H. Wilkinson; *Hon. Secretary*, Dr. A. L. Tárnoky, Royal Berkshire Hospital, Reading.

A REGIONAL training course for laboratory technicians sponsored jointly by the University Institute of Chemistry, Lahore, and the Unesco South Asia Science Co-operation Office will be held at the University Institute of Chemistry, Lahore, Pakistan, during November 23–December 19. Inquiries should be addressed to the Unesco South Asia Science Co-operation Office, 21 Curzon Road, New Delhi, India.

IN a written answer in the House of Commons on July 30, the Chancellor of the Exchequer stated that, to assist the Government in making a review of the control of public expenditure, he was appointing a small group to make a full examination of the whole problem, in consultation with all major departments, and to formulate proposals. Lord Plowden would take general charge of this work, and besides senior officials from departments, including the Treasury, the group would include two or three persons from outside the Government service.

THE Chemical Society has announced that applications for Research Fund grants should be submitted not later than November 14. Further information can be obtained from the General Secretary, Chemical Society, Burlington House, London, W.1.

THE Institute of Physics is organizing a conference during November 13–14 on "Structure Analysis and Experimental Techniques". The conference is to be held at the Institution of Civil Engineers, Great George Street, London, S.W.1. Further information can be obtained from Dr. P. T. Davies, "Shell" Research, Ltd., Thornton Research Centre, P.O. Box 1, Chester.

ERRATUM. In the communication entitled "Prevention of the Onset of Seed Dormancy by Gibberellic Acid", by Dr. M. Black and J. M. Naylor, in *Nature* of August 8, p. 468, in the legend to Fig. 1, for "2 replicates each comprising 50 embryos" read " . . . 2 replicates each comprising 50 caryopses".

SCIENTISTS IN THE PUBLIC SERVICE IN BRITAIN

SPECIAL PROMOTIONS

FURTHER posts have been created in the Civil Service as in previous years under provisions included in the White Paper on the Scientific Civil Service (Cmd. 6679, 1945) to provide for the promotion of individual research workers of exceptional merit. The promotions were effective from July 1, and include the following.

Deputy Chief Scientific Officer

Dr. J. S. Hey joined the Army Operational Research Group in 1940, becoming its head in 1949. In 1952 he formed a research section of what is now the Royal Radar Establishment. Both before and since going to Malvern, he made exceptionally distinguished pioneering contributions to radio astronomy which were the basis for his D.Sc. His work for the Ministry of Supply has also included important contributions on the mechanism of electromagnetic scattering and the ionization associated with discontinuities in hypersonic gas flows, all marked by originality and simple elegance in experimental technique. He is a Fellow of the Physical Society and the Royal Astronomical Society, has served on the Council of the latter and was this year awarded the Eddington Medal. He serves on Commissions of the International Astronomical Union.

Dr. H. G. Hopkins was at the Royal Aircraft Establishment during the war years, working primarily on the theory of elastic stability and of stress distribution in aircraft structure. In 1946 he returned to academic teaching and research. He joined the Armaments Research Development Establishment in 1954 and has been concerned with damage to structures, camouflet and crater formation in soils and dynamic studies in metal plasticity.

Mr. D. H. Sadler is superintendent of H.M. Nautical Almanac Office, the work of which is divided between the highest theoretical and numerical requirements of fundamental astronomy and celestial mechanics: and the practical requirements of astronomical navigation. It was largely due to him that the Royal Air Force had such excellent almanacs and tables during the Second World War. Since then the provision for astronomical navigation, both at sea and in the air, has been much expanded and is now completely unified with that in the United States. Mr. Sadler has contributed much to the theoretical side of navigation and has been awarded the premier awards of both the British (Gold Medal, 1957) and the American (Thurlow Award, 1948) Institutes of Navigation; he was president of the British Institute during the period 1955–56. He is at present general secretary of the International Astronomical Union, and he was secretary of the Royal Astronomical Society during 1939–47. During the Second World War he also directed the computational side of the highly successful Admiralty Computing Service.

Senior Principal Scientific Officer

Mr. J. M. Craddock is serving in the assistant directorate of Dynamical Research in the Meteorological Office of the Air Ministry and is engaged on research into the problem of long-range weather forecasting.

Mr. F. J. Bradshaw, of the Metallurgy Department, Royal Aircraft Establishment, is a fertile research worker on the physics of metals.

Mr. A. G. Earl, of the Guided Weapons Department, Royal Aircraft Establishment, is a research engineer who has studied the fuel system and control systems of guided missiles.

Dr. H. Kolsky, of the Armament Research and Development Establishment, after a distinguished outside career devoted mainly to the mechanics of solids, has recently joined Dr. Hopkins at Fort Halstead.

Dr. E. H. Mansfield, of the Structures Department, Royal Aircraft Establishment, has studied mathematical aspects of aircraft structural research, most recently in connexion with the effects of kinetic heating.

Dr. A. H. Cook (National Physical Laboratory, Standards Division) is primarily engaged in the accurate measurement in absolute terms of certain physical quantities and constants.

Mr. C. G. Giles (Road Research Laboratory) has conducted research aimed at finding ways of reducing the number of road accidents due to skidding.

Dr. A. C. Hulme (Ditton Laboratory of the Food Investigation Board, now of the Agricultural Research Council) works on various aspects of the biochemistry and physiology of apples and other fruits, especially on biochemical changes in respiration during storage.

Mr. A. Silverleaf (National Physical Laboratory, Ship Division) is in charge of the group responsible for research and design in the fields of ship propulsion, cavitation and vibration.

Dr. E. H. Rhoderick joined the Services Electronics Research Laboratory in 1955 and is working at present on very fast switching for computers using superconductors.

Mr. S. B. Kendrick, of the Naval Construction Research Establishment, is an authority on the design of submarine pressure hulls.

Similar promotions have been made by:

(1) U.K. Atomic Energy Authority: Deputy Chief Scientific Officer

Dr. G. E. Bacon spent the war years at the Telecommunications Research Establishment on the development of ground radar equipment, particularly aerial systems. In 1946 he joined the Atomic Energy Research Establishment at Harwell, where he has worked on the application of X-ray and neutron diffraction to the study of the solid state. He is known especially for his work on the structural crystallography of graphite and for neutron studies of hydrogen bonds and thermal motion in hydrated and organic substances.

Dr. W. B. Thompson took up a Harwell Senior Fellowship in 1950 and is now the senior theoretical physicist working on the problems of fusion reactors. His section of the Theoretical Physics Division carries out mathematical investigation into the stability of high-current gas discharges, on the rates of loss of heat from gases at temperatures of more than a million degrees centigrade, and on the effects of magnetic fields on the bulk and particle motions of highly ionized plasmas. The work includes interpretation of the many fundamental experiments in this field carried on in all parts of the world and assessment of its significance to the building of a theory good enough to allow final success in the fusion reactor field.

Mr. W. Walkinshaw is one of Britain's leading particle accelerator theoreticians, joining the Telecommunications Research Establishment in 1940 where he carried out theoretical research on radar and on high-energy particle accelerators. He has worked at the Atomic Energy Research Establishment, Harwell, since 1951. His section of the Theoretical Physics Division is very closely associated with the Rutherford Laboratory of the new National Institute for Nuclear Research, and has been engaged principally on the large 7,000 MeV. proton synchrotron which is still under construction. In addition to this continuing task, the group is charged with the duty of conceiving new types of accelerating machines and specifying designs for other machines of tested types.

Senior Principal Scientific Officer

Dr. K. W. Bagnall is at Harwell in charge of a section of the Radiochemistry Branch of the Chemistry Division which is concerned with research into the chemistry of the actinide and other heavy elements. At present, the main interest is in protactinium.

Dr. A. M. Lane is part of the team of theoreticians whose task it is to ensure that the Atomic Energy Authority is fully armed with the most up-to-date and reliable knowledge of nuclear physics.

(2) Agricultural Research Council : Deputy Chief Scientific Officer

Dr. R. L. Mitchell joined the staff of the Macaulay Institute for Soil Research, Aberdeen, in 1937. He is deputy director of the Institute and head of the Department of Spectrochemistry. Dr. Mitchell has been responsible for the development of spectrochemical methods applicable to the analysis of soils, plants and related materials, involving the evolution of techniques and equipment for arc, spark and flame emission methods. The chemical concentration technique is now quite widely used throughout the world and many overseas workers have visited the Macaulay Institute to study the spectrochemical methods developed by Dr. Mitchell and his co-workers. More than sixty publications describe methods employed and the valuable results obtained in the study of trace element relationships in soils and plants and of the geochemical background to their occurrence. The work of his department also includes the use of infra-red and ultra-violet absorption methods for the examination of organic and inorganic soil constituents.

Senior Principal Scientific Officers

Dr. N. J. Berridge is a member of the staff of the National Institute for Research in Dairying and is well known as an authority on rennin.

Dr. Alan Robertson, of the Agricultural Research Unit of Animal Genetics, Edinburgh, is widely recognized as one of the most successful students of the rapidly expanding subject of population genetics.

Dr. V. P. Whittaker, of the Agricultural Research Institute of Animal Physiology, Babraham, Cambridge, has done outstanding research in the cholinesterase field.

(3) Development Commission : Senior Principal Scientific Officer

Dr. J. W. G. Lund is in charge of the Freshwater Biological Association and has made important contributions to the understanding of the factors which, by controlling the annual phytoplankton cycle, determine the fertility of lakes and reservoirs.

(4) Nature Conservancy : Senior Principal Scientific Officer

Mr. J. G. Skellam is head of the Biometrics Branch of the Nature Conservancy, contributing to mathematical biology, and in particular to theoretical study of population dynamics and statistical ecology.

CONCEPTION OF EVOLUTION

MEETING IN PARIS

THE Muséum National d'Histoire Naturelle celebrated on June 5 the anniversaries of the "Precurseurs et Fondateurs de l'évolutionnisme—Buffon, Lamarck, Darwin" : the 250th anniversary of Buffon's birth, the 150th anniversary of the publication of Lamarck's "Philosophie zoologique", and the centenary of Darwin's "Origin of Species". The meeting was held in the famous Grand Amphitheatre, planned during Buffon's administration, and which, reconditioned about four years ago, is again used for its original purpose. A large and distinguished audience including many famous scientists, some of whom have long been retired, was present.

Prof. Roger Heim, director of the Museum, gave an opening discourse, first summarizing the pre-Buffon period with his customary clarity and grasp of essentials. If in this he appeared to stress the views of naturalists of the old Jardin du Roi it was inevitable, for naturalist-philosophers were almost confined to France at the time—and to the Garden. There were clear statements about transformism before Buffon, and equally there was a belief in the fixity of species after him. An upholder of this was Bosc, one of the founders of the Linnean Society of Paris in 1788, the same year as that of London was started. One of the first acts of the society

was to petition for the erection of monuments in the Garden to the memory of famous scientists, beginning with that of Linnæus, later destroyed by *sans-culottes*.

Prof. Jean Piveteau, of the Sorbonne, a well-known authority on Buffon, gave an account of his personality with particular reference to his ideas on evolution, how they developed and how, at times, they seemed incompatible. A valuable commentary gave the reasons for this, both psychological and diplomatic. Few men are so misjudged in Great Britain as Buffon. He had an enormous influence on the thought of his time. He was a man of wide scientific attainments and in every way a man of the world. His Discourse on Style, delivered on his admittance to the Academy of Sciences in August 1753, has given him his place in literature. This celebrated discourse was read at the meeting by M. Toni Taffin of the Comédie-Française. The audience was obviously thrilled to hear the sonorous phrases which probably all had read—there were at least sixty editions of it in the nineteenth century.

Dr. J. Ramsbottom followed with an account of the lives and work of Jean Lamarck and Charles Darwin. Lamarck first postulated progressive evolution; Darwin put the doctrine of evolution on so sound a basis that it became generally accepted. It was a pleasing acknowledgment of Darwin's epoch-making "Origin of Species" that he should be given a prominent place in what was essentially a celebration of French achievements: moreover, it was logical in realizing that it was the book and not the preliminary announcement of natural selection which was important. So Lamarck and Darwin could be spoken of as searchers after truth without some of the nonsense which has been allowed to belittle the former. Comparing the basic ideas of the two—Lamarck held that an organism in a changing environment is stimulated to vary; Darwin that variation is independent of the environment. For both the environment—adaphic, physical and biotic factors, the last including competition, parasitism, etc.—is all-important. Natural selection is not active like artificial selection, but passive: an organism can live under certain conditions, or it cannot. Lamarck suggested that the simpler animals and plants would provide instructive facts. Evidence accumulated since the introduction of pure culture methods suggests that environmental conditions can produce definite inheritable changes, though not necessarily of the kind Lamarck propounded. The boosting up of penicillin production in *Penicillium chrysogenum* has much in common with what Darwin considered to be the effects of domestication.

Mme. G. Duprat, librarian to the Museum, then gave an account of the career of P. J. Redouté, born in 1759, who was artist to the Garden and painted many of the famous *vélins*. She showed a series of projections of portraits of Redouté and a large number of his paintings, several of which were of specimens from the Royal Botanic Garden at Kew. An exhibition was arranged in the corridor adjoining the amphitheatre showing many of Redouté's original paintings and a number of his published plates; also an announcement of his lectures. The Muséum d'Histoire Naturelle, as one of its main functions, acts as a teaching university. There are at present 24 professors who give courses of lectures covering a very wide field, but there are no degrees awarded as the result of examinations. The system is *sui generis*.

Prof. H. V. Vallois, director of the Musée de l'Homme—attached to the Natural History Museum—gave a history of the Société d'Anthropologie, founded in 1857. In spite of the date the Society's beginning was in no way connected with the publication of the "Origin of Species"; indeed, it preceded it by six months. Social and physical anthropology in the widest sense have been the scope of the Society, and its activities, as outlined, make an impressive history. It is noteworthy how Darwin's name became increasingly prominent after the publication of his "Descent of Man" in 1871. Cuvier, the great exponent of catastrophism, died in 1832, but though there was no successor to stamp out heresies his influence was such that Lamarck's beliefs were still discredited and it was not until Darwin amassed and arranged the evidence that inquiries about the status of fossil man became scientifically respectable.

The last paper, by M. Franck Bourdier, assistant chief of the Service de Muséologie, dealt with the French forerunners of evolution. They make an imposing list far outnumbering the combined total from all other countries. The notion of permanent change in organisms and that of evolutionary sequence stood out clearly. It would be useful to distinguish between them, possibly by speaking of the first as transformism and the second as evolution.

In an adjoining corridor an exhibit was arranged where the matter of this lecture could be studied at leisure and in greater detail. Here again Darwin was included as the end of the old period or as the beginning of the new.

In addition to this intellectual feast and as part of the anniversaries, an excellent exhibition was staged in the gallery of the Botanical Museum, dealing with the history of the doctrine of evolution and illustrating development up to and including man. Specimens, casts, models, photographs and all the modern methods of display provided a most instructive and convincing story.

J. Ramsbottom

X-RAY MICROSCOPY AND X-RAY MICROANALYSIS

The second International Symposium on X-ray Microscopy and X-ray Microanalysis was an independent meeting held in Stockholm in 1959, and sponsored by the same three laboratories as were responsible for arranging the first Symposium, held in Cambridge in 1956: the Department of Medical Physics, Karolinska Institutet, Stockholm; the Departments of Physics and Biophysics, Stanford University, California; and the Electron Microscope Section of the Cavendish Laboratory, Cambridge. The attendance of 180 was 50 per cent greater than that at the previous meeting, although the number of papers presented (74) was not appreciably greater than before (66). The participants were drawn from seventeen different countries and from 120 different laboratories.

The programme was divided according to the nature of the physical techniques employed: X-ray

absorption microradiography, X-ray emission microanalysis, and X-ray microdiffraction analysis. Each division was sub-divided into sections on methodological aspects and equipment, technical applications and biological applications. The number of communications under these three cross-divisions was 43, 10 and 21, respectively, showing that the development of techniques is still enjoying most attention and that their application in biology and medicine is ahead of that in mineralogy and metallurgy.

In absorption microradiography, interest was mainly in the relative merits of the contact and projection techniques, only two contributions being concerned with the reflexion method, in which the correction of aberrations is still the main problem. For qualitative microscopy, all three methods at present have about the same limit of resolving power, at about 0·25μ. H. H. Pattee (Stanford University) has investigated a number of alternatives to the photographic emulsion for recording the X-ray image in contact microradiography, including radiosensitive dyes and plastics, some of which give images which can be enlarged in the electron microscope. J. H. Auld and J. F. McNeil (Aeronautical Research and Defence Standards Laboratories, Australia) showed that xerography with liquid developers allows a resolution comparable with that given by ultra-fine grained X-ray films and at exposure times similar to those of the fastest X-ray films. In the projection method, improvements are being made in the technique of focusing at very high resolution (W. C. Nixon, Cavendish Laboratory) and in obtaining improved contrast (S. P. Ong and J. B. Le Poole, Delft). The main emphasis, however, was on the perfection of the absorption procedure for microanalysis, whether of particular elements (sulphur, phosphorus, calcium) or simply of the dry weight of biological tissues. The contact method has been developed for this purpose, especially in Swedish laboratories, and improvements in the technique were described by Howling and Fitzgerald (New York), Hydén and Larsson (Gothenburg), Lindström and Hoh (Stockholm) and Müller and Sandritter (Frankfurt-on-Main). The accuracy of analysis varies between 5 and 10 per cent, depending on the nature of the specimen. A detailed study of all the factors involved is being made by Henke (Pomona College, California), using red blood-cells as standard specimen. In the projection method direct measurements can be made with a counter on the enlarged X-ray image, thus eliminating the stages of photography and microphotometry, so that the accuracy of analysis is better. In determinations of calcium in bone, Long (Cavendish Laboratory, Cambridge) obtained 2–3 per cent accuracy. The smallest area which can be analysed is a few microns in diameter in either method, the limit being set by the light spot in microphotometry and by the counter aperture in projection recording. The ultimate mass sensitivity is of order 10^{-11}–10^{-12} gm., since sections thinner than 10μ cannot be used.

The applications of absorption microradiography, by one or the other experimental technique, covered a wide range of subjects. In the inorganic sciences, papers were concerned with mineral dressing, petrography and mineralogy; in biology and medicine, with bone (six papers), vascular systems (five papers), other animal tissues (four papers, including a wide survey by Saunders, of Dalhousie University), plant tissues (two papers) and foraminifera (one paper). Most of this work was qualitative, only Lindström (Stockholm) and Sissons (Institute of Orthopædics, London) describing quantitative applications.

X-ray emission microanalysis is more definitely a quantitative method, and rapid progress is being made with its development now that its value in metallurgy and mineralogy has been demonstrated. In biological research, where compounds rather than elements are of interest, its scope is much more restricted. The mechanism of emission is more complicated than that of absorption and in practice results are subject to a variety of corrections. The efficiency of X-ray production by direct electron excitation was discussed by Archard (Associated Electrical Industries Research Laboratory, Aldermaston) and by Cosslett (Cavendish Laboratory, Cambridge), and the corrections for absorption and fluorescence by Philibert (Institut de Recherches de la Sidérurgie, Paris) and by Austin, Richard and Schwartz (Battelle Institute, Columbus). The factors limiting the spatial resolution (or 'localization') of the method were discussed by Duncumb (Cavendish Laboratory, Cambridge), the main factor being the very rapid decrease in electron-beam current as the focal spot is reduced to less than 1μ in diameter. At present the practical limit is about 0·25μ, and further improvement must wait upon developments of the electron source, electron lenses and recording system. A great gain is attainable if a proportional counter can be used for wave-length discrimination, instead of a crystal spectrometer, and Dolby and Cosslett reported promising results with a counter of wide collection angle coupled to an electrical network which can separate the pulses produced by neighbouring elements in the periodic table.

Improvements in the design of microanalysers were reported from the laboratories of Associated Electrical Industries (Aldermaston) and Tube Investments (Hinxton) and from the Cavendish Laboratory. The Associated Electrical Industries instrument is now being manufactured by Metropolitan-Vickers and the first model was on view during the meeting. The production of the scanning microanalyser developed in the Cavendish and Tube Investments laboratories, which displays images of the distribution of selected elements in the specimen, was announced by the Cambridge Instrument Company. The original static spot instrument of Castaing is in production in France, and two similar instruments are now being commercially made in the United States. This activity has been stimulated by the great interest now shown in the method by metallurgists and mineralogists, which was reflected in the papers on applications by Austin, Long, Melford (Tube Investments) and Philibert. All elements with atomic number greater than 11 (sodium) can already be analysed, with an accuracy in favourable cases of better than 0·1 per cent. Since the localization of the analysis can be smaller than 1μ, in depth as well as in diameter, this corresponds to a minimum detectable mass of about 10^{-14} gm. As the range of applications is extended, however, it is becoming clear that the limits of accuracy must be more closely investigated in each special type of alloy or mineral. The work of Philibert on light alloys showed that very careful correction needs to be made for fluorescence effects as well as for absorption of X-rays from one constituent by the others present. To reduce such corrections to a minimum, it will be desirable to build up a collection of reference standards so that one may be selected which is as close as possible in composition to the specimen under

investigation. Comparison of the results obtained in three different laboratories, on the variation of nickel content across tænite inclusions in the same type of meteorite, indicated that standard methods of preparing the specimen must also be worked out. It was unfortunate that only an extended abstract was available of what would have been a most interesting paper by Borovski (Institute of Metallurgy, Moscow), who has independently developed the X-ray microanalyser for metallurgical research. It appears that he has made great progress not only with standardizing the procedures, but also in the automatic recording of concentration curves. His main interest is in diffusion problems and in transfer processes between solid and liquid media.

In summary, it can be said that the emission microanalyser is leaving the stage of being an interesting piece of gadgetry and is now having to prove itself as a routine research tool, in the course of which its capabilities and limitations will become more clearly defined. In particular, it remains to be seen how far it can help in some of the main problems of ferrous metallurgy: exploratory determinations of carbon have already been made by Dolby, but what the limits of accuracy may be and whether carbon and nitrogen can be distinguished from each other are problems still to be solved.

The Symposium ended with two sessions on microdiffraction, which becomes increasingly related technically to X-ray microscopical methods as the advantages of using micro-focus tubes are more widely appreciated. Further developments were described in the tubes themselves and in the spectrometers and micro-beam cameras used with them. The value of the method, especially in reducing exposure time to more practical limits when only very small crystals are available, emerged strongly from the work of Fournier (Centre National pour la Recherche Scientifique, Paris) on crystals from tumours, Mrs. Kennard (National Institute for Medical Research, London) on a number of clinical problems, Skertchly (Textile Physics Laboratory, Leeds) on keratinization of hair, and Wylie (Royal College of Technology, Glasgow) on the growth of crystals in balsa wood. Quite different techniques have been developed for investigating dislocations and other sub-structures in metals, by combining Bragg diffraction with X-ray microscopy. Extensions and applications of this 'Berg–Barrett' method were described by Newkirk (General Electric Laboratories, Schenectady) and Weissmann (Rutgers University, New Jersey). Shinoda and colleagues (Osaka University) had used a transmission variant of the method to investigate the recrystallization of zirconium and its alloys on the micro-scale.

A third symposium is planned for 1962, and will probably be held at Stanford University, California.

V. E. Cosslett

THE BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

THE seventeenth meeting of the Research Panel of the British Gelatine and Glue Research Association was held on June 25, with Mr. S. G. Hudson (Richard Hodgson and Sons, Ltd.) in the chair. In the morning a review of certain aspects of the research of the Association was given by Mr. A. G. Ward, for whom it was the last meeting as director of research, and in the afternoon a discussion on gelation took place, with the main contribution from Mr. J. W. Janus (Kodak, Ltd.).

The review by Mr. Ward was entitled "The Present Position in Gelatine and Glue Research". The paper opened with a reference to a previous review given by the author to the second Research Panel meeting nine years earlier, in which considerable attention was given to those methods of polymer physics and chemistry which were applicable to the study of gelatin. The expansion of research on gelatin now made it necessary to limit the paper to the central problem of the structure of the molecules of the many different types of gelatin. This largely left on one side research on the collagen–gelatin conversion and also on gelation, except where these subjects threw light on the molecular structure of gelatin.

The chemical composition of gelatine, and animal glue, were shown to depend on the amino-acid composition of the gelatin itself, that is to say, of the collagen breakdown products, and on the occurrence and composition of rather small amounts of non-gelatin constituents. Separation procedures such as adsorption on activated charcoal, or '*IRC*50' resin, enabled small quantities of gelatin-free impurities to be obtained and analysed, and examination of fractions prepared with *iso*propyl alcohol showed that about 1 per cent of degraded protein, other than gelatin, might also be present in the residue from fractionation. Using hydroxyproline content as a measure of purity, it was suggested that a total of 3 per cent of organic impurities might be present, although the variation in hydroxyproline content could equally be the result of small differences in composition between gelatin molecules.

Revision of figures for the amide content of gelatines enabled very good agreement to be obtained between the analytical figures for the ionizable groups in gelatin and the results of titration curve determinations. This shows that, within experimental error, all the carboxyl, amino and guanidino groups are free to ionize and are not cross-linked. The accuracy attained did not make it possible to exclude the occurrence of a small number of cross-links involving these groups.

The properties of preparations of well-characterized soluble collagen extracted from calfskin, carp-swim bladder tunic and codskin, by Doty and co-workers, and their conversion of the soluble collagens to gelatin, could be explained in terms of dissociation of the triple-helix collagen structure. The gelatins obtained would, on this view, be single chains, free of cross-links. In contrast, first extract alkali process gelatins have been shown by Courts and Stainsby, using end-groups and light-scattering determinations of molecular weight, to be multichain, at least for the higher molecular weights. The relation between these results was discussed.

The problem of explaining the reduction in gel-forming ability in gelatine caused by neutral and alkaline degradation, although not by acid degradation, as distinct from any effect due to the reduction

in molecular weight, still remained to be solved. Suggested explanations were put forward in terms of internal re-arrangements of the protein chains which upset the ordered arrangement required for a gel bond, or alternatively, that intra-molecular cross-linking occurs progressively on heating under neutral or alkaline conditions, and interferes with subsequent gel formation.

After a brief discussion Dr. A. Courts (British Gelatine and Glue Research Association), in moving a vote of thanks, expressed the appreciation of the staff of the help given to them by Mr. Ward in his term of office. Mr. C. F. C. Simeons (British Gelatine Works, Ltd.), in seconding, added the thanks of the gelatine and glue industry.

Mr. Janus, in opening the discussion on gelation, gave a short paper on "The Formation and Structure of Gelatin Gels". He described the measured properties of gels, the rigidity of the matured gel, the melting-point and the setting time from the sol state, and showed how these depended on solution *p*H. He emphasized that setting might occur in a short time even at room temperature, whereas the gel rigidity increased over long periods at 0° C. The melting-point was, however, much less influenced by low-temperature maturing.

The influence of guanidino content on setting time and melting-point was made clear, but not that on low-temperature rigidity. Interference with setting can also be secured by alkaline copper solutions which are presumed to interact with the >CO groups of the backbone. An interaction between guanidinium groups and the backbone was therefore postulated as the mechanism of the early stage of setting. To explain the continued growth of rigidity at low temperatures, reversion to the helical structure was suggested, and support was drawn from the optical rotation changes.

Dr. R. Collison (British Baking Industries Research Association) presented a short paper by Dr. G. A. H. Elton and himself on "The Swelling of Starch". In this he described the swelling of the granules in water as the temperature is raised, and effects on the mechanical properties. He also mentioned the action of surface active agents in controlling swelling, probably by forming a hydrophobic layer on the granules.

Mr. D. D. Carruthers (University of Durham) described measurements on gelatin gels at high frequency, and discussed the dependence on temperature of the mechanical properties.

The general discussion was opened by Dr. G. Stainsby (British Gelatine and Glue Research Association), who emphasized the difficulty of establishing precisely the mechanism of gelation. The vote of thanks to Mr. Janus and the other speakers was moved by Mr. E. Bradbury (British Cotton Industry Research Association) and seconded by Dr. A. Jobling (British Glues and Chemicals, Ltd.).

ALAN G. WARD

THE TORRY RESEARCH STATION, ABERDEEN

THE Torry Research Station in Aberdeen of the Department of Scientific and Industrial Research, which was set up in 1929, together with its sub-station in Hull, the Humber Laboratory (opened in 1952), carries out research into the problems of fish preservation. The occasion of the open days during June 15–17, when the Station was on show to scientists, equipment manufacturers, the fish industry and the general public, provided an opportunity both of seeing the range of practically the whole of the research in the United Kingdom into fish technology and also of assessing how the treatment of the fish we eat is likely to change in years to come.

Although the fish industry has changed in numerous ways in the thirty years since Torry was opened, it nevertheless remains largely 'traditional'; there are many small firms, mechanization to any substantial degree is found only in a few factories and, with the exception of deep freezing, the methods of preservation used were familiar to our grandparents. Torry, which has been closely concerned in many of the changes which have occurred, is becoming more and more closely occupied with the technical development of the industry of the future. Changes are occurring at an increasing tempo and the next decade is likely to see a much greater alteration in both techniques and organization than the previous 30 years have done.

One of the major problems concerning our supply of white fish is that about half of it comes from Arctic waters. The fishing grounds are anything from three days to one week's steaming from the Humber ports, on which almost all the long-distance trawlers are based, and this consequently sets a limit to the age of the freshest fish that can be landed. Voyages are on an average of nearly three weeks duration and the fish caught first may therefore be 16–17 days old when it is landed. Cod and haddock, even when properly stored in crushed ice, remain in reasonably good edible condition for only 14–15 days. About ½ per cent per annum of the Arctic catch is in fact condemned at landing as unfit for human consumption. After landing, the vicissitudes of the distribution chain may render passable fish unpleasant and good fish only passable.

Since the Second World War, considerable attention has been paid at Torry to the problem of how to get fresher fish to the consumer. A promising solution is to build a trawler capable of freezing the first third of the catch. That the idea is practicable was shown in a full-scale trial carried out in 1955–56 under Torry's technical supervision and financed jointly by the Distant Water Vessel Owners' Development Committee, the White Fish Authority and H.M. Government. A Grimsby trawler was fitted with vertical plate freezers developed at Torry and capable of operating satisfactorily in the exacting conditions of Arctic fishing, and with a −30° C. cold store. The frozen fish was distributed to consumers throughout the country whose reactions were almost universally favourable. The latest development is the design of a vessel of normal size and cost which would show attractive economic advantages over existing high-speed trawlers. Such a vessel would be a trifle slower than the latter, the extra 1–2 knots of which are disproportionately expensive to obtain. It could spend rather longer on the fishing grounds and therefore land a greater weight of fish. The frozen part of

the catch could be used to even out the supply from the summer glut to winter dearth.

Another possible way of slowing down the rate of spoilage of fish is to use antibiotics such as chlortetracycline and oxytetracycline. Much of the pioneer work has been carried out in Canada, where their use is now permitted, but they may not yet be used in the United Kingdom. One of the major tasks in hand is to determine the quantities of these substances likely to get into and remain in the flesh after various types of storage, processing and cooking. Even those antibiotics most effective in fish preservation have limitations; there is little difference in the flavour of fish stored in plain water ice and in antibiotic ice up to about the tenth day, so that no more could be done than to keep fish that would otherwise become poor or very poor in a passable, but not really fresh, state.

A recent survey carried out by staff of the Humber Laboratory and workers seconded by the White Fish Authority of the temperatures of fish during distribution from unloading from the trawler to sale from the fishmonger's slab has stimulated considerable interest within the trade and is already bringing about improvements in practice. It represents another approach to the same problem of how the quality of fish reaching the consumer can be raised. This survey is probably the first large-scale attempt in any country to obtain first-hand field data of this kind. It is typical of much of the work carried out at Torry, since it was made possible only by the co-operation of the industry and was initiated by discussion with representatives of the fish trade.

The Station necessarily supplements such practical applied investigations and development work with a considerable volume of basic research. Thus, a greater understanding is being sought of the detailed structure and composition of fish tissues, and of their behaviour during processing such as freezing and cold storage, smoking and drying. Knowledge is also being acquired of the composition of the bacterial flora of fish and the nature of the species mainly responsible for spoilage. Studies since the War have contributed to improvements in the taxonomy of the marine bacteria mainly concerned and in the building up of a type culture collection now of international reputation.

Solid progress in recent years in the characterization and estimation of the so-called 'extractives' of fish muscle is providing a clearer insight into the autolytic changes that take place immediately after death and during bacterial spoilage. This work is of particular importance in understanding the various physico-chemical changes that occur during dehydration, freezing and subsequent storage of fish, as well as the factors which give rise to different types of spoilage flora under various conditions. Recent years have also seen the accumulation of new knowledge of the main proteins of fish muscle which is serving in particular to explain the causes of textural change during freezing, cold storage and dehydration. Mention should be made of the work on the Maillard 'browning' reactions which occur in dehydrated fish muscle.

Considerable attention has been given to the prevention of oxidative rancidity in cold-stored fatty fish. Fish fats are highly unsaturated, and frozen fatty fish such as herring remain in really edible condition for a shorter period than white fish. The rate of oxidation of fish fat can be slowed down by 'glazing'; this consists of dipping the frozen fish in water so that a layer of ice is formed around the outside. Drying of fish in cold store hastens the development of rancidity; even more important, therefore, is to store fatty fish under conditions where drying is at a minimum. Current work on the oxidation process may eventually lead to economic improvements. It has been found that fat oxidation is catalysed by hæmatin pigments in the red lateral muscle which is present in a well-defined form only in fatty fish.

Nevertheless, there are limits to the cold-storage period even of species like cod which contain considerably less than 1 per cent fat in the muscle; the fat becomes oxidized and there are progressive changes in the protein structure common to all fish. Recently, a new method has been devised for assessing the development of toughness in cold-stored fish. This depends upon the fact that although fresh unfrozen muscle can be macerated in dilute formalin solution to give a thick opaque suspension, there is a tendency for the fibres of frozen fish to resist maceration and this resistance increases as a function both of storage time and of storage temperature. By determining the amount of light transmitted by the 'soup' of fish fibres produced under standard conditions it has been found possible to relate samples to a standard time/temperature curve. This test, the validity of which requires further checking to cover a number of variables, is so simple that it could easily be adopted by the fish-freezing firms which, with one or two notable exceptions, do not employ scientifically trained staff and do not possess quality control or development laboratories.

Fish freezes more rapidly than it thaws, due to the difference of thermal conductivity through frozen and unfrozen tissue. For example, a block of fillets 4 in. thick may freeze in 4 hr. or so but may take 20 hr. to thaw out in air at ambient temperatures. A number of firms use large quantities of frozen fish for their products; for example, there is a variety of ready-cooked fish products prepared initially from frozen fish and sold in frozen consumer packs, and the kippering industry uses large amounts of frozen herring when fresh herring is not available. At present, fish is thawed on a large scale, either by merely leaving the frozen blocks in air or by spraying with cold water. The latter method, if it is carelessly carried out, may adversely affect the quality of the product, and both methods are time- and labour-consuming. Attempts by workers in other countries to apply dielectric heating have not been successful, mainly due to 'runaway' heating. This is the condition in which there is progressively increasing absorption of the available power in warm spots in the blocks, which become cooked; this is at the expense of the cooler portions, which remain frozen. Recently this difficulty has been overcome and commercially available equipment has been slightly modified: a pilot plant has been running at Torry without trouble for the past six months or so. Blocks of frozen fish can be evenly thawed in about 15 min. The technological implications of this work are very wide indeed.

The commercial smoking of fish is still largely carried out in the traditional smoking kiln which was developed during the early Middle Ages. This is merely a chimney in which brined fish is hung and a sawdust and wood-chip fire lighted on the floor. The operation takes anything up to 12 hr. or more to complete. The irregularity of natural convection, and the effect of warm humid weather on the functioning

of the kiln, render fish-smoking an art which is difficult to practise. In 1939 a mechanical kiln was developed at Torry which simplified the process and made it much easier to control. Although the industry was at first slow to adopt the new kilns, an increasing number of firms are now doing so. Intriguing possibilities are, however, now being suggested as a result of basic physical and chemical work on the composition of wood smoke. It has been shown that virtually all the smoke constituents on smoked fish are derived from the invisible vapour phase and not the visible particulate phase. The practicability of smoking fish with 'smokeless' smoke and further developments as well are envisaged.

There is a continuous programme of work at Torry on the improvement of the efficiency of conventional fish-meal plant. Emphasis is put upon methods of increasing production, plant efficiency and nutritive value of the product.

It is important to stress that the high standing of the Torry Research Station within the fish industry itself is very largely due to the considerable amount of consultation and discussion which takes place with the industry and, not less important, the very good relationship built up between individual scientists and various people 'in the trade'. Much of the development and survey work carried out within the past ten years would have been quite impossible without the close and friendly co-operation of the industry; on this personal contact between government research workers and the industry the future development of this relatively undeveloped and traditional industry, without any research organization of its own, depends. G. H. O. BURGESS

FISHERY RESEARCH

DR. BREDER has prepared a valuable review of work on social grouping in fish*; it also contains new data, though it is sometimes a little difficult to pick these out. He discusses in detail the various types of groups: the aggregation, where the individuals are not 'polarized'; the school, where they are; and the pod, where the fish are in physical contact. These types of groups are illustrated by outstandingly good photographs, those of pods and fish in 'orderly files' being the most interesting.

Descriptions of new work are mainly of the effect of light intensity and colour on a number of species and the analysis of the internal structure of schools. In the experiments on the effect of the wave-length of light the fish were given a choice between different colours, the intensity of the different colours being equated photometrically. No attempt was made, by determining the spectral sensitivity of the fish, to equate the subjective intensity, or intensity as it appeared to the fish. Of particular interest are Dr. Breder's discussions on the leadership of schools, the school as a super-organism and the evolution of schooling behaviour. There is also a section on schooling in terms of cybernetics, where the point is made that the survival of a species which has grouping tendencies should perhaps be considered from the point of view of how they have got over the danger involved, rather than that such tendencies automatically have survival value.

Dr. Loukashkin's and Dr. Grant's work on *Sardinops caerulea**, a species of great commercial importance, has much in common with Dr. Breder's but is more limited in extent. It is again well illustrated with photographs. Like other clupeoids, *Sardinops* is not an easy subject for experiment, but results have been obtained which show the importance of light for the maintenance of school formation and that fright reactions are elicited by red lights and by flashing white lights. When given the choice between red, green, blue and white light, the fish avoided red and preferred blue and green to white. As in Dr. Breder's work, this technique has a limitation in that the intensities of the different colours were not equated subjectively but only photometrically.

This type of behaviour work, which may be considered important as an aspect of fisheries research, is now being produced in much greater quantity than before the War, and it is particularly welcome to the fisheries research worker when it is concerned with species of commercial importance.

J. H. S. BLAXTER

* Bulletin of the American Museum of Natural History. Vol. 117, Article 6: Studies on Social Groupings in Fishes. By C. M. Breder, Jr. Pp. 393–482 + plates 70–80. (New York: American Museum of Natural History, 1959.) 1.50 dollars.

* Proceedings of the California Academy of Sciences. Vol. 29, No. 15: Behavior and Reactions of the Pacific Sardine *Sardinops caerulea* (Girard) Under the Influence of White and Colored Lights and Darkness. By A. S. Loukashkin and N. Grant. Pp. 509–548. (San Francisco: California Academy of Sciences, 1959.)

THE ONTARIO RESEARCH FOUNDATION

THE annual report of the Ontario Research Foundation for 1958 (pp. 36. Toronto: Ontario Research Foundation, 1959) includes, besides the report of the director, Dr. H. B. Speakman, a summary of the work of the various sections, a list of papers published during the year, the financial statement and details of the Board of Governors and professional and technical staff. There is also a list of grants for postgraduate studies in science for the period 1958–59, for which grants in 1958 totalled 145,204 dollars. In biochemistry three major projects, dealing with the development of an all-temperature biscuit spread for the Defence Research Medical Laboratories, tea, and the recovery of pure individual amino-acids from wheat gluten after hydrolysis, were completed, and two major studies are in progress under the Rice Mills Fellowship. In chemistry, activity was maintained at a high level. The three-year survey of air pollution of the Hamilton area was completed, while the development of gas chromatography proceeds apace. In a study of factors controlling the crystallinity of polymers, techniques developed for preparing polymers of butane with 50 per cent of crystallinity are being used to study the relation between the type of catalyst and polymer structure. A novel ion-exchange process for recovering ammonia

from ammonia-base waste sulphite-liquor has been developed and a pilot plant constructed. A comprehensive study has been continued of various sulphite-liquors and their fractions and has led to a patent application ; there have been utilization studies on by-product lignin from the manufacture of vanillin, while research on phosphate glasses has been continued in the Na_2O—P_2O_5—H_2O system centred largely on the constitution of sodium acid glasses of intermediate composition, using filter paper chromatography.

In engineering and metallurgy basic research was directed at the concentration of hæmatite by a combination of magnetic and mechanical methods or by roasting methods followed by magnetic separation. In work on dry magnetic separators the 'Fast Eccentric Drum Separator' has been developed to the point of commercial production. In basic research on the fatigue of metals three stages have been distinguished : (*a*) the first four thousand cycles ; (*b*) a slow steady decline in cyclograph (magnetic test) ; and (*c*) the last 15,000–20,000 cycles in which the final crack is developing. A precision camera was designed and built for stress determination in X-ray work.

In the Department of Parasitology most of the work was a continuation of earlier projects, and persistent effort has provided an understanding of the prevalence and mode of transmission of some of the many parasites of Ontario's wild animals. Similar studies on wild birds are in progress, and during 1958 the blood parasite of ducks, *Leucocytozoon simondi*, was successfully grown on tissue culture in test-tubes. Continued studies of two types of blood parasites of birds have shown that certain types of black flies transmit them to ducks, while others transmit them to ruffed grouse. In physics some fundamental work dealing with beams of electrons has been planned, while other projects included development of an atmospheric X-ray spectrometer, design procedures for dynamic pressure stages, determination of gas density by electron beams and high-energy applications of electron beams. The Department of Physiography completed an extensive study of the fine sand fraction of representative soils and a five-year environmental study of soya bean is nearing completion. Research on the chemical modification of wool continued in the Department of Textiles as well as a study of the colour fastness of spun-dyed viscose yarn. Good progress is reported in the standardization of women's and children's garment sizes for the Canadian Government Specifications Board.

INSTRUCTIONAL FILM RESEARCH IN PENNSYLVANIA

THE Pennsylvania Instructional Film Research Program was established in 1947 and terminated in 1955. Jointly sponsored by the U.S. Army and Navy, it represents the largest piece of co-ordinated research yet carried out on the teaching film. Accounts of the early part of the research have appeared in *Nature*[1]. It is the purpose of this article to complete the outline record by reviewing the last reports—now gathered into one volume[2].

The later work follows directly on the earlier, confirming it, filling in details and dealing with specific problems. But some new and interesting notions of a general sort arise in this process. The very last studies, 100–104, deal with training aids such as models and other apparatus that are not films. Two of the studies, 46 and 50, are related to the use of films in psychotherapy. These two studies, as well as study 60, are concerned with films which influence attitude. The main classes of films dealt with in the research have been those which impart information and those which teach perceptual-motor skills.

A number of the studies yield information of general practical use. For example, study 37 by Philip Ash and Nathan Jaspen—see report *SDC* 269–7–37—examines optimum viewing conditions. Using a small rear projection daylight screen in teaching a performance skill—the assembly of a gun breech block—the optimum viewing area was found to be a sector 60° wide and 12 screen-widths deep. Increasing distance from the screen beyond 12 screen widths led to much sharper loss of teaching effectiveness than increasing angle of view beyond that of the 60° boundary. Outside the optimum viewing area loss was greater under daylight than under dark viewing conditions. These results may be compared with those found for a standard size screen and projector by J. J. Gibson[3] : he found that within a sector up to 90° wide and 7 screen-widths deep there was no loss in teaching effectiveness.

The Pennsylvania film research organization has always stressed that teaching films should be tested "with adequate samples of appropriate target audiences using reliable and valid tests", rather than by viewing panels. Nevertheless, assessing teaching effectiveness by a viewing panel remains often the only practical alternative. Study 57 by L. P. Greenhill investigates such assessing, and recommends a particular type of film analysis form (or questionnaire) ; this panel testing procedure being used to select the best of several films, or to improve the teaching effectiveness of a film still under production. Study 59 by A. L. Edwards provides a statistical methodology which might be used when assessing films by the panel method. The report on study 48 about making simple demonstration films with untrained personnel includes—as an appendix—a 'manual for minimum film production'.

Infra-red photography offers an excellent means of recording audience reactions—of children and others—under conditions of little or no visibility. But infra-red motion photography is expensive. Study 56, by L. P. Greenhill, investigates the less costly use of infra-red memo-motion photography. This is essentially time-lapse photography. The photographs were taken on 16-mm. infra-red film at the rate of one a second, a rate which appears sufficiently frequent to show most types of human activity. The record was synchronized with the events on the screen, by the synchronous drive of camera and projector, and more satisfactorily by the use of a mirror reflecting a small image of the screen into the camera—so as to appear at one corner of each memo record frame.

In one of the earlier Pennsylvania studies[4] it was found that a rating profile for a film, showing peaks for an audience reaction of 'I am learning' and

valleys for a reaction 'I am not learning', provided a valid index of learning. The subjectively based graph was found to be highly correlated with one based on the results of an objective learning test. This finding—although it has yet to be fully established—has considerable importance in connexion with film research, because it justifies a simple procedure in place of the present elaborate one of objective testing. In some measure it is further confirmed by study 55. In this study, by Richard M. Fletcher, it was found that a team of competent assessors could shorten film commentaries without reducing teaching effectiveness considerably more when aided by a learning profile than when not so aided—in one case 26 as against 11 per cent. However, Richard M. Fletcher says that the results of this study should be interpreted carefully. In an interesting discussion of results he considers the implications of the reactions 'I am learning' and 'I am not learning'.

The notion of 'realism' as a factor influencing the teaching effectiveness of films has received attention in early Pennsylvania studies, in relation to viewing angle[5], stereoscopy[6] and colour[7]. It emerges as a more conscious notion in the later work. In study 49 on the validity of pictorial tests and study 47 on the use of films in a Thematic Apperception Test, 'iconicity' is considered. This term derives from C. Morris's work. "A sign is iconic to the extent to which it itself has the properties of its denotata[8]." The study of the features and combinations of features that lead to life-likeness in films has been called by the present reviewer 'simulacrics'[9]. In listing eight hypotheses of film research it is possibly significant that the director of the Pennsylvania research should have given the sign similarity hypothesis first. "That films whose signals, signs, and symbols have high degrees of similarity ('iconicity') to the objects and situations which they represent will be more effective for most instructional purposes than films whose signals, signs, and symbols have low degrees of 'iconicity'[10]."

Report 40 provides a valuable bibliography of production, utilization and research on instructional films. It contains about 600 references dating up to the early part of 1952, arranged alphabetically by author.

One or two of the early Pennsylvania studies have been criticized on the grounds that they are directed towards findings that are obvious in the first place. Perhaps more justifiably one or two other of the Pennsylvania studies have been criticized because they have been concerned with teaching in general rather than teaching with films in particular. The Pennsylvania research includes relatively little basic research on the film medium itself. In general the method has been to carry out experiments using the prevailing current picture-cum-commentary type of instructional film, and consequently to improve that type.

But such comment on isolated studies and minor aspects of the Pennsylvania research seems almost out of place in view of the enlightened way it has been directed and all it has accomplished. In 1947 there was no body of experimentally attested principles about teaching films and no proved techniques of film research, which thanks to the Pennsylvania work exist now. This work—which might so easily have been restricted to fulfilling limited training needs—has yielded results of value to teachers generally and to psychologists. Credit is due to the associate directors C. R. Carpenter and L. P. Greenhill, who with some of their staff now form an organization at Pennsylvania State University that has already investigated the use of closed-circuit television in university teaching.

C. DENIS PEGGE

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[2] Technical Reports *SDC* 269–7–37 –59 and *SDC* 269–7–100 –104; obtainable singly or in one volume (*SDC* 269–7–61), from Special Devices Center, Port Washington.

[3] Gibson, J. J., Report No. 7, Army Air Forces Aviation Psychology Program (Washington, D.C., Government Printing Office, 1947).

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BLOOD GROUPING OF THE REMAINS OF SWEDENBORG

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EMANUEL SWEDENBORG was born on January 29, 1688, and died in London on March 29, 1772. He was interred in the vault of the Swedish church in London. His remains were disturbed on several occasions; an account of these was given by Hultkrantz[1]. The coffin was first opened in 1790, and there is little doubt that this unauthorized action made the removal of the skull possible. The vault was opened at least nine times between this date and 1816. It has been suggested that a skull was stolen from the coffin on two occasions between 1816 and 1817. In consideration of the vogue enjoyed by phrenology at this time, this is not a remarkable fact. On the first occasion the instigator was probably the famous phrenologist Captain Holm, whose collection already included the skulls of Alexander Pope and Casimir Périer. The presence of a Swedenborg skull in his collection was disclosed to his niece in 1845, but regarded as a family secret. There is some evidence that Holm introduced a substitute into the coffin. In a letter to *The Times* of April 4, 1823, Hawkins states that the skull was removed in 1817, by Captain Granholm, a Swedish sailor, for financial gain. On his death this skull passed into the possession of Wahlin, pastor of the Swedish church in London. A skull claimed to be that of Swedenborg was in the collection of Charles Tulk, M.P., in the years prior to 1823, and it is thought

possible that Wahlin gave it to him for safe keeping. Tulk had casts made of this skull just before it was replaced in the coffin on March 25, 1823, in the presence of Wahlin. This is the skull now present in the coffin. There is no conclusive evidence as to its authenticity in the documents available. In 1908 a letter was received at the Swedish Legation in London, from an individual claiming to have seen Swedenborg's skull in the collection of an antiquary in the 1870's. It would seem probable that this is the skull from Holm's collection, but the evidence obtained to date is not conclusive. This skull was traced, and is now in the possession of Dr. Charlotte Brandt. Distinction between the two skulls would appear to be possible only by means of objective scientific tests. These have now been undertaken by Prof. Folke Henschen and his colleagues in Stockholm, and at his request blood group analysis has been carried out at the British Museum (Natural History).

The material available from Uppsala consisted of portions of the parietal and mastoid bones of the skull (treated as one specimen in the blood grouping tests), a metacarpal bone, part of the right femur, fragments of a cervical vertebra, and soft tissue from two regions of the right arm. The last two samples included portions of cloth. The 'English' skull, which has been described elsewhere[2], was entrusted to us by the present owner, Dr. Charlotte Brandt. Measurements of this skull are available in the records of the British Museum (Natural History) and a full description will be published with the complete account of studies on the remains of Swedenborg in the *Acta Regiae Societatis Scientiarum Upsaliensis*. From this skull a section of the left parietal bone was cut out with a high-speed circular slitting saw, and diploic tissue removed with a dental drill. This method has allowed replacement of the section without visible evidence of the action of the saw or drill. The removal of sufficient material for testing would not have been possible from a skull by other methods without visible damage. Bone from the skeleton was also prepared by drilling or by pulverizing in a mortar. The flesh samples were separated as nearly as possible from the accompanying cloth with forceps.

The technique of blood grouping employed is essentially similar to that discussed by Boyd and Boyd[3] and modified by Candela[4] for application to bone. This technique is one in which evidence of the presence of a group specific antigen may be presumed if antiserum of suitable strength is inhibited in its activity with red cells of the appropriate group, after it has been in prolonged contact with the tissue sample. Four naturally occurring human anti-A sera and four anti-B sera were used on each specimen, where the quantity of material available permitted this. These were diluted to bring the resulting titres of absorbed and unabsorbed sera to a convenient level for titration purposes. It was found that for any one serum these titres always fell within a range of three tubes. Titrations were carried out with a fresh 2 per cent suspension of A_2 and B cells[5]. In all cases these antisera were known to give satisfactory results with control material of known blood group (that is, typed during life).

Candela's technique has been slightly modified, as follows: 0·2 gm. of prepared tissue was placed in a 75 × 10 mm. tube and 0·4 ml. antiserum added to each sample. After careful mixing the tubes were placed in the refrigerator for 24 hours, and at the end of that time centrifuged at moderate speed for 2–3 min. The supernatant was removed to a clean tube, using a Pasteur pipette with a small cotton-wool wad around the tip[6]. If bone particles had not been completely removed, the tubes were re-spun. Titration was carried out as described by Boorman and Dodd[5]. Buffered saline containing 1 per cent sodium azide as preservative was used throughout. No result has been accepted as positive unless a consistent inhibition was observed with any one serum over the entire series of tests. Results in all cases are based on a series of at least four tests on the same sample, using a technique of replacement of the same antiserum. Table 1 shows the inhibition values for the femur from Uppsala, on one anti-A and one anti-B serum from the series. It illustrates the standard of inhibition on which the determination of the blood group has been based.

Table 1

Test No.	Serum					
	Anti-A			Anti-B		
	1 : 16	1 : 32	1 : 64	1 : 64	1 : 128	1 : 256
1	+	−	−	++	+	(+)
Control	+++	++	+	++	+	w
2	+	−	−	++	++	+
Control	++	+	w	++	++	+
3	(+)	−	−	+++	++	w
Control	+++	++	+	+++	++	w
4	++	(+)	−	++	+	vw
Control	++	+	w	++	+	w

In at least one other laboratory anti-A sera are reversed with anti-B sera on each sample (Gray, personal communication). This method could be unreliable because of the presence of alcohol-soluble group substances in all sera[7], and it has not been found to give clear results in this laboratory. In using a replacement technique over a series of tests it has been found possible to confirm or reject results which on first testing appear doubtful, and this method is therefore preferred.

The Uppsala remains were tested together, but the 'English' skull was not obtained at the same time, and was therefore tested in conjunction with a further sample of the Uppsala skull at a slightly later date. All this material had a very fresh appearance, giving a strong smell on drilling. The diploic tissue of the 'English' skull, in particular, appeared to contain a large quantity of organic matter, but when allowance had been made for the different environmental conditions in which each had been preserved, no difference of sufficient significance could be observed which would allow of any distinction in the historical age of the two specimens (Table 2). Fluorescence under ultra-violet lamp showed no distinction between the two skulls in comparison with the long bones.

Table 2

Nitrogen content of the material:

Coffin skull	4·5–4·8 mgm. nitrogen per 100 mgm. bone.
'English' skull	3·9–4·1 mgm. nitrogen per 100 mgm. bone.
Coffin femur	4·4– mgm. nitrogen per 100 mgm. bone.

In discussing the results obtained on these bones, it is relevant first to consider the present-day distribution of the ABO groups in Sweden. Jesper Swedberg, father of Emanuel, came from Dalekarlia, although his mother was of German origin. Figures for this area of Sweden are available from the paper by Beckman[8] (Table 3).

Table 3

	No.	O	A	B	AB	p	q	r	D/σ
Beckman (Kopparberg) (conscripts)	7,952	39·94	44·05	11·54	4·46	28·28	8·36	63·36	+ 1·33
London*	37,216	46·43	41·57	9·16	2·85	25·53	6·23	68·27	0·70

* Means of six series quoted in ref. 9 (the small series of Dyke being omitted).

It will be seen from these figures that a high frequency of group A is characteristic of the population. Assuming the possibility that the Uppsala skull, if a substitute, may have been English, we must also consider the distribution of the ABO groups in London (Table 3).

Inhibitions obtained from this material, although not strong, were consistent, with the exception of the flesh samples. In these, while a clear inhibition for group A was obtained, some inconsistent absorption was seen with anti-B sera. Conclusions as to the blood group of the skeleton have been based, therefore, on the results obtained from the femur, the cervical vertebra, and the metacarpal bone. These give inhibition of all anti-A sera, and none with anti-B sera. The Uppsala skull shows the same result. The 'English' skull failed to show any inhibition with any anti-B serum and with one of the four anti-A sera, and had ceased to inhibit the three remaining anti-A sera at the fourth test. In view of the very clear evidence offered with anti-B sera it is felt that the interpretation of these results may be made with confidence, and the presence of group A-specific substances postulated in all the samples. As has already been noted, the distribution of this blood group in the postulated areas of origin of the material made this result probable. It has not proved possible, therefore, to distinguish between the two skulls on the evidence afforded by blood grouping.

In considering the possibility that these results may be due to the presence of contaminants, it must be borne in mind that in consideration of the known history of the bones, it might reasonably be inferred that they had not been buried in soil. The evidence offered by Thieme, Otten and Wheeler[10] on the action on group-specific substances of certain anaerobic saccharolytic bacteria present in soil might therefore be considered irrelevant to the present study. It has been suggested that substances present in the soil, such as the Forssman antigen, may give results ascribable to group A substances[11], but no evidence has been brought forward. Other sources of bacterial activity remain possible, however, and it was thought to be of interest to submit unlabelled samples of both skulls and of the femur from the coffin to Drs. Allison and Perkins, of the National Institute for Medical Research, for the detection of bacterial contamination. Acid hydrolysates of this material were submitted to paper chromatography, for the detection of muramic acid and diaminopimelic acid. These are known to be constituents of bacterial cell-walls, but have not been detected in human tissues. These substances could not be shown to be present in the Swedenborg material. This result excludes gross bacterial contamination, but it remains to be shown whether the presence of bacteria in amounts sufficient to absorb blood group antibodies can be detected by the chromatographic technique. Should this prove to be so, the use of this technique in conjunction with the blood grouping of tissues should prove a valuable tool to the palæo-serologist.

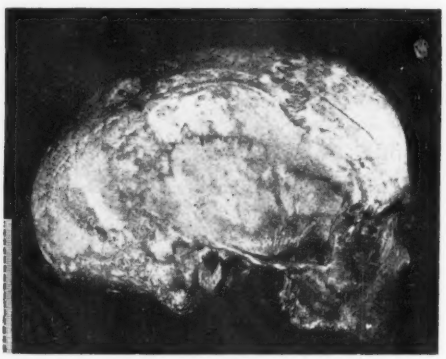

Fig. 1. The 'English' skull attributed to Emanuel Swedenborg (*Norma lateralis*)

As it was reported (Henschen, personal communication) that large quantities of lead salts were present in the bones, a study was made on control material of known blood group to determine whether increased quantities of lead salts would affect the results of blood testing. The normal quantity of lead present in the long bones is 1·88 mgm. per 100 gm. In a series of tests this quantity was increased until it reached twice the normal value. No effects on the results of blood grouping were noted.

While the use of palæo-serological technique has proved its value in the identification of human remains, it has not contributed to any decision in the case discussed here. However, it has been established that on the basis of blood grouping the 'English' skull has an equal claim with the Uppsala skull to be that of Swedenborg, and that it should be included in further investigations. Tests being carried out in Sweden, under the direction of Prof. Henschen, may prove of greater assistance in distinguishing between the two skulls. It is expected that results of their examination will be published in the *Acta Regiae Societatis Scientiarum Upsaliensis*.

I am indebted to Mr. G. C. Ross for the estimations of nitrogen content of the bones quoted in this communication.

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ABNORMAL HUMAN HÆMOGLOBINS

Human Hæmoglobin *E*: the Chemical Effect of Gene Mutation

THREE of the many abnormal variants of human adult hæmoglobin (*A*) occur in high frequency in certain areas of the world. They are sickle cell hæmoglobin (*S*), hæmoglobin *C* and hæmoglobin *E* (ref. 1). All these are thought to be caused by mutant genes inherited in a Mendelian manner. Such evidence as is available suggests that the genes for hæmoglobins *S* and *C* are allelic or closely linked[2]. The only family so far known in which hæmoglobin *E* occurred with another abnormal hæmoglobin (*S*) was one studied in Turkey by Aksoy and Lehmann[3]. The evidence for allelism, or close linkage, of the two genes was conflicting, but the authors felt that it was more in favour of allelism than against.

Comparisons of the chemical structure of hæmoglobins *S* and *C* with that of normal hæmoglobin (*A*) have not only confirmed the allelic nature of the hæmoglobin *S* and *C* genes, but have also shown the effects of these mutations on the primary chemical structure of hæmoglobin[4]. We now wish to report similar studies on hæmoglobin *E* which we undertook in order to investigate the chemical effect of this mutation and the chemical and genetic relationship between hæmoglobin *E* and the other abnormal hæmoglobins.

Hæmoglobin *E* was discovered in 1954 by Itano, Bergren and Sturgeon[5] in an American patient of Guatemalan, Spanish and Hindu origin—and in his family—by its abnormal electrophoretic mobility. The gene for hæmoglobin *E* has since been found with high incidences among Burmese and Siamese and some Indonesian, Ceylonese and Malaysian populations[6]. Single instances have been found in India, Persia, the Philippines[6], and among the Eti-Turks[3] (who have a high incidence of the sickle cell gene). It is interesting to note that the hæmoglobin *E* gene is found with high frequency in south-east Asia, whereas the hæmoglobin *S* and *C* genes are found in highest incidence among the Negroes of Africa[1]. In other words, they are geographically widely separated, but all three forms resemble one another in occurring very much more frequently than the other abnormal hæmoglobins. The chemical relationship between hæmoglobins *A*, *S* and *C* was reported by us[4] to be very close indeed, since it involved a replacement of the same glutamyl residue in hæmoglobin *A* by a valyl residue in hæmoglobin *S* and a lysyl residue in hæmoglobin *C*. Since the countries in which the hæmoglobin *S* and *C* genes occur are close together, and since the gene for hæmoglobin *E* occurs mostly in a separate region, it seemed possible that hæmoglobin *E* is not so closely related to *S* and *C*. This was found to be the case; a different part of the hæmoglobin molecule is affected by the mutational change.

On moving-boundary or paper electrophoresis at *p*H 8·6 (ref. 7) hæmoglobin *E* moves close to hæmoglobin *C* but slightly faster; on the other hand, at *p*H 6·5 its position is close to hæmoglobin *S*, though just behind it. This contrasts with the behaviour of hæmoglobins *A*, *S* and *C*, which migrate in the same relative order at *p*H 8·6 and at *p*H 6·5, hæmoglobin *A* being the fastest and hæmoglobin *C* the slowest. The intervals between them are almost equal. Hence, the effective net charge difference between hæmoglobins *A* and *E* at *p*H 6·5 cannot be the same as that between hæmoglobins *A* and *C*. The amino-acid compositions of hæmoglobins *A* and *E* are not significantly different[7]. The number of sulphydryl groups found by amperometric titration are the same in both hæmoglobins *A* and *E* (ref. 7); the solubility of hæmoglobin *E* is about the same as hæmoglobin *A* (ref. 5). Hence the difference between the hæmoglobins *A* and *E* is likely to be small and probably involves charged groups.

In the present work, hæmoglobin *E* from individuals known to be homozygous for the hæmoglobin *E* gene was denatured by heat at *p*H 8. It was then digested with trypsin at *p*H 8, following the course of the breakdown by alkali uptake in a *p*H-stat[4]. At the end of the reaction a core resistant to trypsin was precipitated at *p*H 6·5. Treatment with hydrochloric acid–acetone removed the hæm group from the core, which could then be completely solubilized by digestion with chymotrypsin[4].

Such tryptic and chymotryptic digests of hæmoglobin *E* yielded mixtures of peptides which were compared with those of hæmoglobin *A* in two ways. First, they were separated by fingerprinting[4], and secondly, by paper electrophoresis in the pyridine–acetic acid buffer at *p*H 6·4 (ref. 8) and examination of the peptide bands so formed by descending chromatography with *n*-butyl alcohol/acetic acid/water (4 : 1 : 5)[9].

When fingerprints of the chymotryptic and tryptic digests of hæmoglobin *E* were compared with those of hæmoglobin *A*, all the peptides occupied the same positions except peptide 26, which had been replaced by a new peptide, called 26*a*, in the hæmoglobin *E* tryptic digest (Fig. 1). Separation of the peptides by the second method revealed another new peptide, called 26*b*, in the tryptic digest of hæmoglobin *E*. It therefore appears that one peptide present in the tryptic digest of hæmoglobin *A* is replaced by two new ones in hæmoglobin *E*. No other changes have so far been found. Within the limits of our experimental method[4], the amino-acid compositions of the unchanged peptides in the tryptic and chymotryptic digests were found to be the same in hæmoglobins *A* and *E*.

The hæmoglobin peptides *A*–26, *E*–26*a* and *E*–26*b* were isolated by eluting the appropriate peptide bands obtained by paper electrophoresis of the tryptic digests at *p*H 6·4. The hæmoglobin *A* peptide 26 required no further purification. The hæmoglobin *E* peptide 26*a* was purified by repeating the electrophoresis at *p*H 6·4, and the hæmoglobin *E* peptide 26*b* by descending chromatography with *n*-butyl alcohol/acetic acid/water (4 : 1 : 5)[9].

The amino-acid sequences of the differing peptides were determined by the techniques of Sanger[10] and of Edman[11]. Quantitative amino-acid analysis by two-dimensional paper chromatography[12] showed the composition of the hæmoglobin *A* peptide 26 and those of the hæmoglobin *E* peptides 26*a* and 26*b* to

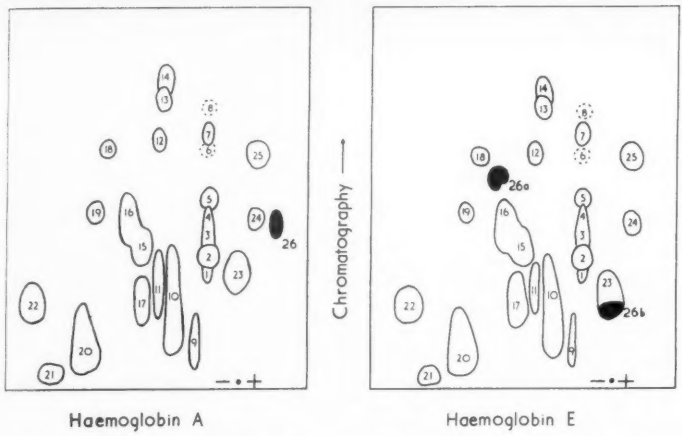

Fig. 1. Tracings of fingerprints of the trypsin digests from hæmoglobin *A* and *E*

be as shown in Table 1. The composition of the hæmoglobin *A* peptide has been confirmed by analysis on the 'Spinco' Model 110 Moore and Stein automatic analyser. When the compositions of the two hæmoglobin *E* peptides are added, they account for all the amino-acids present in the normal peptide with the addition of a single lysine residue in place of a glutamic acid.

Table 1. Composition of Hæmoglobin *A* Peptide 26 and of Hæmoglobin *E* Peptides 26*a* and 26*b* (expressed as Residues of Amino-Acid per Mole of Peptide)

	Hæmoglobin *A* peptide 26	Hæmoglobin *E* peptide 26*a*	26*b*
Aspartic acid	2	—	2
Glutamic acid	2	—	1
Alanine	1	1	—
Glycine	3	1	2
Leucine	1	1	—
Valine	3	—	3
Arginine	1	1	—
Lysine	—	—	1

Partial amino-acid sequences of the peptides were obtained from the results of partial acid hydrolysis, and end-group determinations of the fragments by Sanger's 1-fluoro-2,4-dinitrobenzene method[11]. The N-terminal sequences of the hæmoglobin *A* peptide 26 and the hæmoglobin *E* peptide 26*b* were found by examining the dinitrophenol-peptides obtained by partial acid hydrolysis of the dinitrophenol-derivatives of the two peptides, and also by three steps of the Edman degradation[11] using the modification of Sjöquist[13]. The remaining portion of the sequence of the hæmoglobin *A* peptide 26 was finally determined by digestion with elastase[14] and quantitative amino-acid analysis[12] of the resulting fragments. When the peptide was heated in dilute acetic acid[15], it was found that nearly two molecules each of aspartic acid and valine had been split from the peptide, leaving the rest intact. As shown in Fig. 2, it is still not yet possible to give a complete sequence for the hæmoglobin *E* 26*b* peptide, although peptides of structure glu(val,gly) and val-gly must be fitted into the undetermined region in some way. It is highly likely that the sequence in the hæmoglobin *E* 26*b* peptide corresponds exactly to that of the hæmoglobin *A* 26 peptide segment except that the C-terminal lysine replaces the glutamic acid in hæmoglobin *A* 26 peptide.

The occurrence of amide groups in these peptides has yet to be investigated, but the electrophoretic behaviour of the parent hæmoglobins *A* and *E* suggests that the glutamic acid which is replaced has a free carboxyl group.

It is assumed that hæmoglobin *E* contains two equal half-molecules, as do hæmoglobins *A* and *S* (ref. 16). Fig. 2 shows that the change in hæmoglobin *E* resides in a replacement of a glutamyl residue of hæmoglobin *A* by a lysyl residue in hæmoglobin *E*. This is the only difference so far detected among nearly 300 amino-acids of the hæmoglobin half-molecule. The amino-acid substitution is like that found in hæmoglobin *C* (ref. 4), involving a change of two charges, and the two proteins have a similar electrophoretic mobility at *p*H 8·6, but in this case it occurs in a different tryptic peptide and hence in a different part of the protein molecule.

It is interesting to note that, just as in the case of hæmoglobins *S* and *C*, the genetic mutation which is responsible for producing hæmoglobin *E* expresses itself as a replacement of a single amino-acid by another. We can only guess that this alteration is somehow functionally important, and confers a selective advantage on its bearer which is sufficiently high to account for its frequent occurrence[17]. The chemical mechanism underlying the effect is as yet obscure. The amino-acid change which we find explains the electrophoretic mobility of hæmoglobin *E* at *p*H 8·6, but not its behaviour at *p*H 6·5. While it cannot be stated with complete assurance that there is no other amino-acid alteration in the hæmoglobin *E* molecule, no other charge difference has so far been detected among the peptides, nor have any differences in their amino-acid compositions been found.

Aksoy and Lehmann[3] have suggested that the gene for hæmoglobin *E* is an allele of, or closely linked to, the gene for hæmoglobin *S* (and hence to that for hæmoglobin *C*). In these last two proteins the change in the identical amino-acid suggests that the mutations occupy identical loci in the deoxyribonucleic acid chain forming the hæmoglobin gene. The locus of the hæmoglobin *E* mutation is likely to be some distance away from the *S* and *C* loci, but may, nevertheless, be closely linked in the usually accepted genetic sense. The finding that peptide 4 (hæmoglobin *S* and *C* mutations) and peptide 26 (hæmoglobin *E* mutation) are found to be in the same β-peptide chain of hæmoglobin[18] supports the idea of close linkage.

We wish to thank Drs. H. Lehmann and E. R. Huehns (London) for generously supplying the samples of hæmoglobin *E* used in this investigation, Dr. G. Braunitzer (Munich) for his gift of a large quantity of hæmoglobin *A* peptide 26, and Drs. M. F. Perutz and F. H. C. Crick (Cambridge) and Dr. H. Lehmann for their helpful

Hæmoglobin *A* 26 val-asp-val- asp-glu-val-gly -gly - *glu* - ala-leu-gly-arg.

Hæmoglobin *E* 26*b* val-asp-val-(asp-glu-val-gly)-gly - *lys*.

26*a* ala-leu-gly-arg.

Fig. 2. Amino-acid sequences of hæmoglobin *A* peptide 26 and of hæmoglobin *E* peptides 26*a* and 26*b*

interest in this work. One of us (J. A. H.) is indebted to the Medical Research Council for a Scholarship.

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Hæmoglobin 'Bart's': a Fœtal Hæmoglobin without α-Chains

In a previous communication one of us reported[1] that normal fœtal hæmoglobin (*F*) consists of two kinds of polypeptide chains. One of these (α) is identical with the α-chain of adult hæmoglobin, while the other (γ) is different from its adult counterpart (β) and seems to be characteristic of the fœtal form. (To avoid confusion in nomenclature of the hæmoglobin chains, it has been decided to call the chains of hæmoglobin *F*, α and γ and not α and β-fœtal as in ref. 1.) A fœtal hæmoglobin with an abnormally high anodic electrophoretic mobility was discovered at St. Bartholomew's Hospital in an infant whose red-cell morphology resembled that seen in thalassæmia[2]. It was called hæmoglobin 'Bart's'. We have now found that this consists of γ-chains only.

Fresh blood from an infant with hæmoglobin 'Bart's' was made available by the courtesy of Dr. H. Kohler, of Birmingham. A purified solution, containing about 4 mgm. of hæmoglobin 'Bart's' in 15 ml., was obtained by elution from paper electrophoretograms. This solution was adjusted to *p*H 6·9 and heated in a boiling water-bath for 20 min. to precipitate the hæmoglobin. This was dissolved in 0·1 *N* hydrochloric acid and the hæm extracted with acid acetone[3]. The dried globin was suspended in 0·6 ml. of 2 per cent ammonium bicarbonate buffer at *p*H 7·9, and digested by addition of 0·05 mgm. of trypsin at 38° C. After 2 hr. the solution was evaporated and re-evaporated from acetic acid to sublime the ammonium carbamate formed. A solution of chromatographically purified hæmoglobin *F* (ref. 1) of the same concentration was treated in exactly the same way in a parallel experiment. The digests were compared with a normal tryptic digest[1] of hæmoglobin *F* by both one-dimensional paper electrophoresis at *p*H 6·4 and by fingerprinting[4].

The 'fingerprint' of hæmoglobin 'Bart's' is shown in Fig. 1 in comparison with those of hæmoglobin *F* and the α- and γ-chains of hæmoglobin *F* (ref. 1). It is apparent that all the α-chain peptides are missing from hæmoglobin 'Bart's' and that it consists solely of γ-chains. Its sedimentation constant is indistinguishable from that of *A* (R. A. Kekwick), which suggests that its molecular weight is about 68,000 and the globin a tetramer.

Jones, Schroeder, Balog and Vinograd[5] have found that hæmoglobin *H* consists solely of β-chains of adult hæmoglobin associated in a tetramer. Hæmoglobin 'Bart's', therefore, is the exact counterpart in the fœtal system of hæmoglobin *H* in the adult system. Hæmoglobin *H* is only found in the presence of the gene for thalassæmia. The blood picture of infants with hæmoglobin 'Bart's' is like that in thalassæmia, but this does not persist into later life, nor do the children develop an abnormal hæmoglobin. There are then two possible explanations for the production of an all γ-chain hæmoglobin. There may be an over-production of the γ-chains. However, from our present data we cannot be certain that there does not exist a small chemical difference between the γ-chains in hæmoglobin 'Bart's' and those in hæmoglobin *F*. Alternatively, the production of α-chains may be inhibited, in which case, since the children with hæmoglobin 'Bart's' do not develop hæmoglobin *H*, the α-chains of hæmoglobin *A* and *F*, although chemically identical, do not appear to be controlled by the same gene. Thus in a Greek boy with thalassæmia in whom, as is typical for this condition, hæmoglobin *F* had persisted beyond the age of infancy, a small amount of hæmoglobin 'Bart's' was

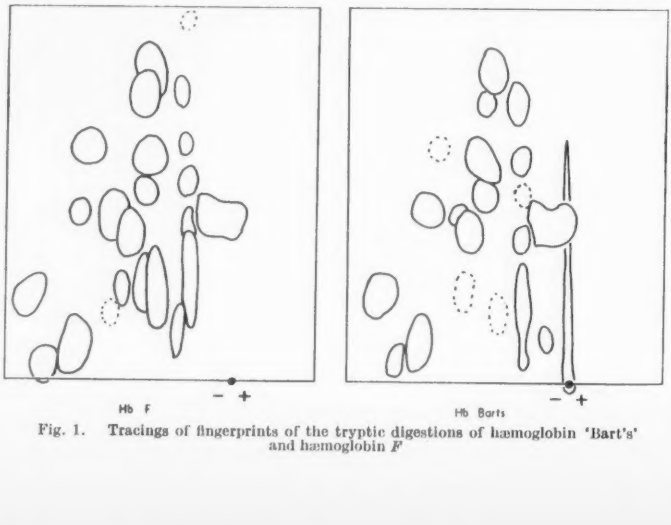

Fig. 1. Tracings of fingerprints of the tryptic digestions of hæmoglobin 'Bart's' and hæmoglobin *F*

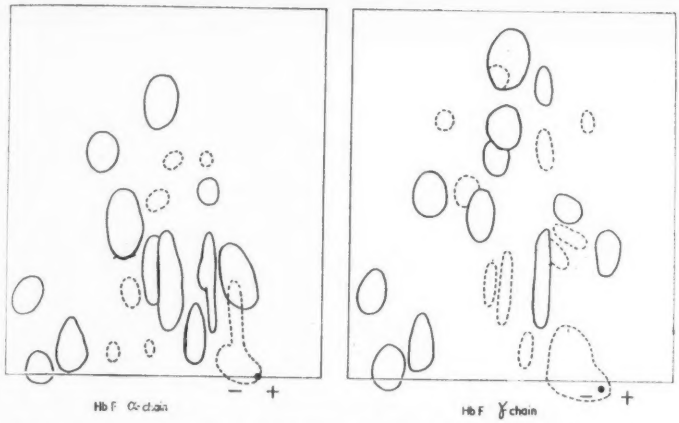

Fig. 2. Tracings of fingerprints of the tryptic digestions of the chains of hæmoglobin *F*

also found but no hæmoglobin *H*[6]. This could be interpreted as demonstrating the independence of the production of the α-chains for hæmoglobins *A* and *F*. On the other hand, in an adult woman from Israel with a thalassæmia-like blood picture, more than 80 per cent of hæmoglobin *A* and only traces of hæmoglobin *F* were found, but 8 per cent of hæmoglobin 'Bart's' and 5 per cent of hæmoglobin *H*[7]. Of her four children one also possessed hæmoglobins *A*, 'Bart's' and *H*, but only a trace of *F*. This represents a strong inhibition of the fœtal α-chain formation with only a weak inhibition of that of the α-chains for hæmoglobin *A*.

Several infants with hæmoglobin 'Bart's' have now been seen, always associated with normal hæmoglobin *F*, and it is interesting that in these infants the γ-chains of fœtal hæmoglobin should be capable of a separate existence, even though α-chains are being produced for both hæmoglobins *A* and *F*. No reports of hæmoglobin consisting entirely of α-chains have yet appeared, but it would not be surprising if such chains could also exist on their own.

One of us (J. A. H.) is grateful to the Medical Research Council for a scholarship.

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MECHANISM OF IMMUNOLOGICAL UNRESPONSIVENESS

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CONDITIONS of immunological unresponsiveness which vary in specificity, completeness and duration have been induced in new-born rabbits by administering small amounts of soluble proteins at birth[1–4], and in adult rabbits by the injection of massive doses[5] of antigens, or by the prolonged administration of moderate amounts of antigens[6,7]. In the hope of emphasizing pathways of antigen distribution that are essential for the establishment of an immune response, studies were undertaken to determine whether the fate of labelled antigen in unresponsive rabbits differs from the fate in normal rabbits which are potentially responsive[8]. For this purpose, New Zealand white rabbits were rendered specifically unresponsive by means of repeated intraperitoneal injections of iodoproteins begun within 12 hr. of birth[9]. The iodo-ovalbumin and the iodobovine serum albumin which were injected contain 8–10 per cent of iodine and when injected intraperitoneally to normal adult rabbits they consistently evoke the production of precipitating humoral antibodies specific, in part, for their determinant diiodotyrosine residues.

In no case, however, were precipitating antibodies found in the sera of rabbits which had been injected repeatedly 4–6 months from the time of birth. The methods used to trace the iodoproteins were essentially the same as those employed in previous studies[8]. Preparations of the iodoproteins labelled with iodine-131 were injected intravenously to normal and unresponsive rabbits. Measurements were made after intervals of 2 min.–24 hr. of that portion of the persisting iodine-131 that was insoluble in aqueous 7 per cent trichloracetic acid and in neutral alcohol and acetone. Because the radioactive iodine is an integral part of the determinant groups of the iodoproteins, it is felt that measurements of protein-bound iodine-131 trace the fate of material that is potentially antigenic, possibly in contrast to measurements of the total persisting isotope. It was found that the labelled iodoproteins were eliminated from the blood and distributed among the organs of unresponsive rabbits in the same way as in normal, adult rabbits. After a day, less than 0·5 per cent of the total injected iodoprotein remained in the blood of rabbits of both types. Since the inability to form antibody induced by the present procedures does not result in a persistence or 'tolerance' of the antigens in the unresponsive rabbits, there is no evidence that the iodoproteins are 'recognized-as-self' by the unresponsive rabbits, or that the unresponsiveness depends on a mechanism for eliminating the iodo-

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proteins more rapidly than normal. Inasmuch as the patterns of intracellular localization in the cytoplasmic granules of the livers and spleens of the unresponsive rabbits were exactly the same as those observed previously with iodo-ovalbumin and certain azoproteins[8,10], it is clear that the presence of foreign antigenic material in cytoplasmic granules, while possibly a condition that precedes or is necessary for antibody formation[11], is not in itself a condition that leads inevitably to the production of measurable amounts of precipitating antibody.

Of the many possible interpretations of these findings only one will be considered, namely, that the presence of antigen or haptenic fragments of degraded antigen may actually function to forestall antibody formation. It is proposed that antibody formation is initiated as usual in a small number of susceptible cells whenever normal or unresponsive rabbits receive antigen. However, the first molecules of antibody that are formed are likely to encounter cytoplasmic granules that contain residual antigen derived from the final injection, or (in the case of unresponsive rabbits) partially degraded haptenic residues remaining from previous injections of antigen. Intracellular antigen–antibody reactions at appropriate loci could release the hydrolytic enzymes that are normally retained within the membranes of granules such as the lysosomes[12].

If the damage inflicted on essential structures by the reaction itself, or by the enzymes released or activated through the reaction, were sufficient to annihilate such cells, there would fail to be established a permanent line of cells that possessed the specific information necessary for antibody formation during the time when undegraded, antigenically potent antigen was still present in the rabbit. Direct evidence is already at hand that the addition of antigen to tissue breis or to sera that contain specific antibody results in the activation of proteases[13–15]. It is anticipated that a similar activation will follow the addition of antibody to sera, to homogenates of tissue, or to subcellular fractions that contain specific antigen. Damage by proteases that are activated by immunological reactions has been suggested repeatedly over the years[14,16] as a reasonable basis for pathological changes at the tissue-level that occur in states of hypersensitivity. The present suggestion is that under certain conditions such damage would not extend beyond individual cells in which antibody formation had been initiated. The fact that induced immunological unresponsiveness is not permanent, unless antigen is continually administered[4], is attributed to the gradual loss (by degradation or by dilution) of haptenic residues from the potential antibody-forming cells, or to a fortuitous asymmetric distribution to daughter cells of the discrete granules that contain the antigen.

Many more data are required before it will be possible to decide whether a number of phenomena already recorded in the literature are manifestations of some of the cellular events postulated here. Insurmountable difficulties may confront attempts to assign microscopically visible effects unequivocally to macroscopically imposed causes, particularly when the effects that are judged as pertinent to the argument could be exceedingly rare events. Nevertheless, it may be significant that degenerating, fragmented nuclei are found beside viable, primitive cells in the germinal centres of the lymphoid follicles, particularly during the natural immunization that accompanies bacterial infections[17]. This paradoxical phenomenon is enhanced by immunization with antigens ordinarily regarded as innocuous. Since a few molecules of antigen may be adequate to initiate antibody formation, while a relatively large amount of antigen may be required to ensure complete annihilation of antibody-forming cells, it is possible that the remarkable action of adjuvants (see ref. 18) is to minimize the flood of antigen into the cytoplasmic granules of potential antibody-forming cells so that survival is more probable if the improbable events occur that culminate in antibody formation.

It is noteworthy that application of the fluorescent antibody techniques of Coons to adult rabbits has shown that antibody is rarely detectable in cells that take up antigen, where devastating intracellular antigen–antibody reactions would be possible[19]. Moreover, the antibody within germinal centres of stimulated lymph nodes is limited not only to individual cells, as in the medullary area, but occurs also "over an area of the follicle involving a number of cells in an indistinct way, often with a particulate distribution between the cells as well"[19]. Antibody distributed in this manner may correspond to debris from cells which undertook antibody production while excessive amounts of antigen were still present in cytoplasmic particles. On the other hand, antibody, but rarely antigen, is easily detected in members of the plasma cell series[19,20]. The superficial injury that plasma cells are liable to suffer as a result of an extracellular antigen–antibody reaction, rather than causing cell death, may form what is frequently overlooked by many theorists, a concrete basis for the specific proliferative stimulus that must underlie the secondary response. The mechanism which must be modified (or selected) in order for appreciable amounts of antibody to be formed appears to reside in cells that are highly sensitive to X-irradiation. Once it is established, however, the antibody-forming mechanism is remarkably radioresistant[21]. Although cells with different morphological properties appear to be involved at the beginning and at the end of the overall process of antibody formation, the striking qualitative differences of these cells with respect to radioresistance might depend upon the cellular locus of antigen–antibody reactions, rather than a fundamental change in cell type. Perhaps death is an inevitable sequel to X-ray damage in cells that are also damaged by intracellular antigen–antibody reactions, while antibody-forming cells may survive X-irradiation in the absence of additional intracellular damage from antigen–antibody reactions. Very recently, it was suggested[22] that X-irradiation destroys within minutes the ability of cells in lymphatic tissues to derive energy from nuclear phosphorylation reactions. The intracellular antigen–antibody reactions postulated here might be expected in addition to derange alternative, cytoplasmic reactions that otherwise could have produced energy utilizable for survival and for eventual repair of the X-ray damage.

Many previous theories of antibody formation have failed to provide adequate explanations for the fact that the secondary response is more intense than the primary response (for a discussion, see ref. 19). On the other hand, certain versions of the 'selection theory', which currently enjoys much favour[23], appear to neglect the same fact viewed from the other direction, that the primary response is much less intense than the secondary response. In the outline of the proposals presented here, the secondary response is assumed to depend upon a stimulation to

proliferate that is selective for lines of cells that have inherited, or otherwise acquired, the specific information needed to synthesize antibody, which information was initially established in the few surviving cells that were modified as a result of the primary encounter with antigen. The absence of a "suitable environment"[24] that was postulated to account for the failure of appreciable formation of antibody in new-born rabbits, even when competent cells were transferred from normal adult donors, may depend upon a possible deficiency of metabolites essential for survival and necessary to repair the intracellular damage caused by antigen–antibody reactions in individual cells where antibody formation was initiated.

That transfer to new-born rabbits of lymphatic tissue from immunized donors is followed by formation of antibody[24] would depend upon the existence in the transferred tissue of cells in which the antibody-forming mechanism is free from potentially lethal intracellular antigen. Natural tolerance towards self-materials and experimentally induced tolerance towards homografts, where many of the antigenic determinants that are involved still await chemical characterization, may also depend upon the selective destruction of cells in which auto-antibody formation is initiated. The accidental survival of a few such cells, if followed by the passage of the antibody-forming mechanism into cells that are impervious to 'antigen', would explain the development of conditions of auto-immunization.

The finding that iodoproteins appear to undergo the same fate in unresponsive rabbits as in normal rabbits has suggested simple mechanisms which might account for specific unresponsiveness and for a number of other immunological phenomena. However, it is clear that the experiments have not clarified the ultimate problems of where and how the information necessary for the synthesis of a specific combining site is materialized, or whether this information exists in cells prior to a primary injection of the antigen.

A complete and more critical account of the experimental studies which form the basis of this discussion is being prepared for publication. This work was supported by the United States Public Health Research Grants *E*-1296 and *E*-1296(*C*). We are indebted to Dr. Joshua L. Edwards for many informative and stimulating discussions, and for making available the opportunities and facilities that made the studies possible. One of us (F. R. F.) has received support from U.S. Public Health Service *RG*-4801 (*C2S1*). [May 13

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HYDROGENATION OF LIPIDS BY RUMEN PROTOZOA

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IT has been observed by several workers that dietary unsaturated fats are modified in the rumen by hydrogenation. Shorland, Weenink and Johns[1] found that the fatty acid composition of ingested plant material was considerably changed by rumen contents. In particular, the high content of linolenic acid was markedly reduced, being converted mainly to stearic acid. This work was confirmed by Shorland, Weenink, Johns and McDonald[2] when they demonstrated that rumen contents *in vitro* could hydrogenate oleic, linoleic and linolenic acids. Other studies on hydrogenation include those by Hoflund, Holmberg and Sellmann[3] using cows fed linolenic acid, Reiser and Reddy[4] with goats fed on a diet supplemented with unsaturated oils, and more recently Garton, Hobson and Lough[5] with sheep. The type of micro-organism responsible for the hydrogenating activity has not been determined in these studies.

It has been observed that some species of protozoa are able to ingest chloroplasts[6]. Since chloroplasts are rich in lipid material, particularly unsaturated fatty acids, it was thought likely that these ciliates may be responsible for at least some of the hydrogenation occurring in the rumen.

Rumen contents were collected from a rumen-fistulated cow fed on fresh red clover (*Trifolium pratense*) and the protozoa allowed to settle by gravity. Microscopic examination of the protozoa showed a mixed population of holotrichs and oligotrichs, the latter group being mainly Epidinia. Washed suspensions of the ciliates were prepared by the procedure described by Oxford[6] using an acetate–bicarbonate–phosphate buffer containing penicillin and neomycin. After washing to free them of bacteria, the protozoa were suspended in the buffer with antibiotics to which the substrate and clover starch were added. The flasks were incubated under carbon dioxide at 38° or 4°. After overnight incubation, the lipid material was extracted from the solution by acidifying with hydrochloric acid and extracting with petroleum ether. The fatty acids were isolated by the usual methods and their iodine numbers calculated by the Hanus procedure. Under these

Table 1. HYDROGENATION OF SODIUM LINOLEATE AND LINSEED OIL BY A SUSPENSION OF RUMEN PROTOZOA

Incubation temperature	Substrate	Iodine number
4°	Sodium linoleate	162·6
38°	Sodium linoleate	101·2
4°	Linseed oil	160·0
38°	Linseed oil	120·0

conditions, hydrogenation of both linoleic acid and linseed oil was found (Table 1).

The hydrogenation of chloroplast fat was next examined by incubating protozoa with chloroplasts. A suspension of chloroplasts was prepared by grinding freshly picked red clover leaves in an end-runner mill with a sucrose–phosphate buffer solution[7]. After removing the fibrous material by filtration through muslin, the filtrate was centrifuged at 100*g* for 10 min. to remove large plant particles and the supernatant centrifuged at 1,500*g* for 20 min. to sediment chloroplasts. The chloroplasts were suspended in the acetate–bicarbonate–phosphate buffer plus antibiotics and equal volumes added to two 100-ml. conical flasks containing washed protozoa suspensions, one of which had been placed in a boiling water-bath to destroy enzyme activity. The flasks were flushed with carbon dioxide and then incubated at 38° C., provision being made for the release of gas from the flasks.

After incubating overnight, the boiled control sample was still green in colour, but the test sample was coloured yellow, indicating breakdown of chlorophyll. The samples were freeze-dried and the lipids extracted by boiling with diethyl ether. The ether solutions were evaporated to dryness, taken up in petroleum ether and the solvent removed *in vacuo*. The lipids were saponified and fractionated into water-soluble, non-saponifiable and fatty acid fractions. The fatty acids were converted to the methyl esters and analysed by gas-liquid chromatography. Considerable differences were noted between the test and control sample fatty acids (Table 2).

The composition of the C^{18} acids in the boiled control sample is typical of red clover chloroplast lipid (Weenink, R. O., personal communication).

Table 2. COMPARISONS BETWEEN C^{18} FATTY ACID COMPOSITION OF CHLOROPLAST LIPIDS INCUBATED WITH LIVE OR DEAD RUMEN PROTOZOA
Fatty acids weight per cent

Sample + Chloroplasts	Saturated	Unsaturated		
		mon-	di-	tri-ene
Live protozoa	17·5	10·6	27·6	44·3
Boiled protozoa	10·7	16·2	2·8	70·3
Difference	+6·8	−5·6	+24·8	−26·0

There has been considerable conversion of triene acid to diene acid and monoene to stearic acid. Only a slight conversion of diene to monoene seems to have occurred. This is rather surprising since it was shown above that protozoa could hydrogenate linoleic acid. Reiser[8] suggested that rumen contents convert linolenic acid merely to linoleic acid although Shorland *et al.*[1] showed further hydrogenation of linoleic acid to monoene and saturated acids. Since a considerable amount of linolenic acid still remained in these protozoa experiments, there must have been an excess of unsaturated lipid present and it may be possible that the enzyme or enzymes responsible for hydrogenation show some degree of specificity and attack the triene and monoene acids preferentially. Since little is known about the mechanisms of enzymic hydrogenation, this must remain speculative at the moment.

The non-saponifiable material from both samples was yellow in colour, had similar intensities and spectra typical of a carotene–xanthophyll mixture. In spite of the carotene being highly unsaturated, little hydrogenation of the pigment has occurred. This is in agreement with the observations made by Shorland, Weenink, Johns and McDonald[2].

In spite of attempts to wash the protozoa clean of external bacteria, some bacteria were undoubtedly present inside the ciliates. Their role in hydrogenation is difficult to assess; but it seems likely that they were not present in great enough numbers to have much effect. Preliminary experiments using washed suspensions of rumen bacteria suggest that bacteria do not contribute a great deal to the hydrogenation occurring in the rumen. It is interesting to speculate whether fluctuations in the population of protozoa could be correlated with the seasonal variation in iodine numbers of milk fat noted in New Zealand[9].

Further studies on the role of bacteria and individual species of protozoa in lipid metabolism are in progress. I would like to thank Miss J. Michael for technical assistance, and Dr. J. C. Hawke and Miss J. Cook, of the Fats Research Laboratory, Wellington, for the gas–liquid chromatography data.

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FORMATION OF THE PORPHYRIN RING

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IT is generally agreed that the naturally occurring porphyrins arise through the condensation of four molecules of porphobilinogen (I). However, it has proved very difficult to formulate a sequence of reactions leading uniquely from porphobilinogen to the type III and type I porphyrins. Several years before any of the reactions leading to porphyrin formation were recognized, Turner[1] had realized that the essential clue to the understanding of the cyclization of the porphyrin ring was to be found in the behaviour of tripyrrylmethanes, established by Corwin *et al.*[2,3]. Shemin, Russell and Abramsky[4] and Bogorad and Granick[5] have elaborated these ideas. In the course of the isolation of isotopically labelled hæmin from duck red blood cells[6], Shemin

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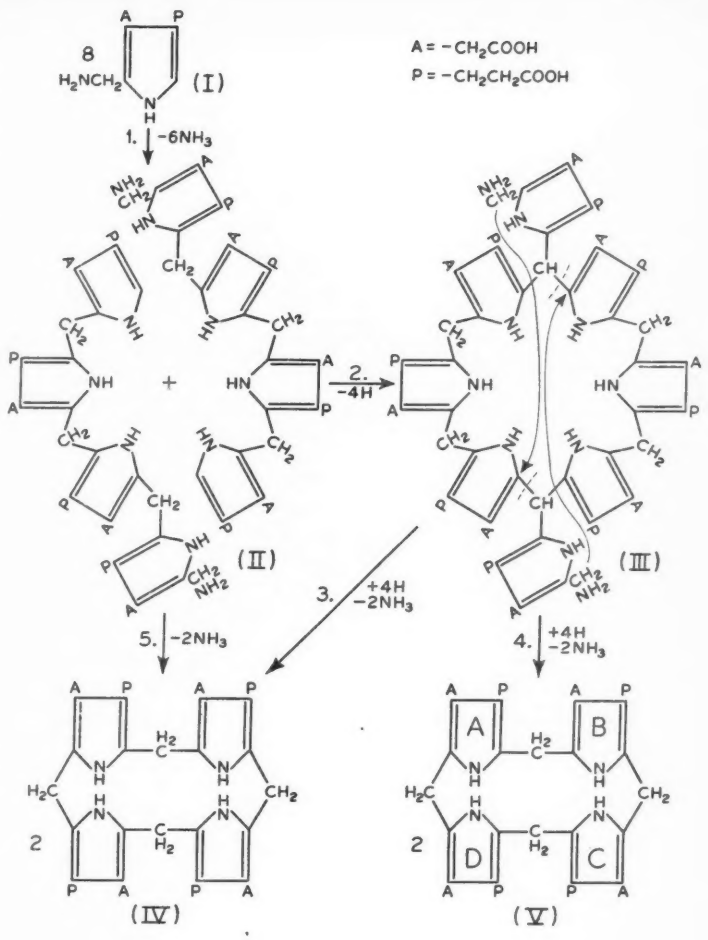
and I (unpublished work) encountered a colourless, stable, intensely radioactive, protein-bound material, which was thought to be a polypyrrole. On the strength of this finding, compounds containing several pyrrole rings were considered as possible intermediates in the condensation of porphobilinogen (I) to the uroporphyrinogens (IV, V), the parent substances of the porphyrins. If Turner's tripyrryl-methane hypothesis is coupled to the idea that the rearrangements leading to the type III porphyrins occur within a single large molecule, a mechanism for porphyrin formation emerges which not only satisfies all the chemical requirements put forth below but also provides a rational interpretation of the results of Bogorad's[7-9] elegant enzymatic studies. This formulation has the virtue that it reveals the unique structure of the type III porphyrins to be a necessary consequence of the chemical structure of the key intermediate, a cyclic octapyrrole (III), in their formation.



The primary requirement to be fulfilled by the octapyrrole hypothesis is that it must lead to the formation of only type III and type I uroporphyrinogens (V and IV respectively) since type II and IV isomers are not formed enzymatically[7,8], and type II and IV porphyrins do not occur in Nature. Furthermore, the isomeric specificity must be independent of the action of enzymes and reside in the chemical nature of the reaction since, in the presence of hydrochloric acid, (I) is converted largely to (V), with the formation of lesser amounts of (IV)[10,11]. These conditions are met by reactions 4, 5 and 3. In addition, the octapyrrole hypothesis fulfils all the following subsidiary requirements: all four pyrrole rings of the porphyrin must arise from a single common precursor (I), in agreement with the very exact equivalence of the isotope concentrations in the neutral and acidic pyrroles of hæmin formed from isotopically labelled precursors[6,12,13]. All of (I) consumed in the reaction must be converted to porphyrin without the obligate formation of pyrrolic by-products, in agreement with the more than 90 per cent[14] or 80 per cent[8] conversion of (I) to porphyrins achieved enzymatically, or the 77·5 per cent conversion achieved in the presence of hydrochloric acid[11]. All four of the methene bridge carbon atoms must be derived from the aminomethyl side-chain of (I), in agreement with the isotope data[6].

Most of the schemes of porphyrin formation hitherto proposed (refs. 4, 5, 11, 17; and reviewed in refs. 15, 16) do not account for the formation of porphyrins I and III uncontaminated by other isomers, nor can they account for the very high yields of uroporphyrin-III formed from porphobilinogen.

Formaldehyde may be a product of the enzymatic and non-enzymatic conversion of (I) to porphyrin[4]. This would constitute strong evidence against the present proposal only if the formaldehyde were shown to arise in stoichiometric amounts from the aminomethyl group of (I).

The octapyrrole hypothesis may be stated in conjunction with Bogorad's recent enzymatic work[7-9]. He finds[7] that the enzyme porphobilinogen deaminase converts (I) to (IV). However, since a second enzyme named 'uroporphyrinogen isomerase' has as its sole substrate a product (different from IV) of the action of porphobilinogen deaminase on (I) (ref. 8), it appears necessary to postulate that an as yet undetected colourless compound is the primary product of the action of porphobilinogen deaminase. The structure of this material must be such that it is easily convertible, either spontaneously or under the further action of porphobilinogen deaminase, to (IV) (reaction 5). The suggestion is advanced that this unknown compound is the linear tetrapyrrole (II), and that the primary action of porphobilinogen

deaminase is to convert porphobilinogen (I) to a linear tetrapyrrole (II) (reaction 1).

The enzyme 'uroporphyrinogen isomerase' acts to yield uroporphyrinogen-III (V) as its first detectable product[8,9]. The suggestion is advanced that the function of this enzyme is to condense two molecules of (II) (reaction 2), thus introducing the two tripyrrylmethane structures of (III), and the primary product of its action is the cyclic octapyrrole (III). The cyclic octapyrrole is considered to undergo re-arrangement, either spontaneously or under the further action of the 'uroporphyrinogen isomerase' preparation, to yield two molecules of uroporphyrinogen-III (V) (reaction 4). (An analogous reaction leading to (IV) (reaction 3) will be shown to be less probable.)

The overall result of this sequence of reactions is the interchange of the pyrrole moieties destined to form rings *D* of the porphyrins between two tetrapyrroles, with a consequent reversal of the position of the rings *D*, relative to the other pyrrole rings of the tetrapyrroles.

An approximate model of (III) demonstrated that reactions 4 and 3 can take place only if the two asymmetric tripyrrylmethane carbon atoms are of the same configuration, and that if this is so the two 'branch' pyrroles must lie on the same side of the plane of the major ring. The entire structure can be bent so that the 'branch' pyrroles pass each other and their aminomethyl groups are brought into apposition with the alpha positions of the pyrroles opposite in the ring. The simultaneous attack of both aminomethyl groups on the appropriate pyrrole alpha carbon atoms (indicated by arrows in the figure) with consequent scission (indicated by dotted lines) of both tripyrrylmethane moieties leads to rearrangement of (III) to two molecules of (V) (reaction 4). The preferential formation of uroporphyrinogen-III (V) would appear to be a consequence of interactions between the carboxyethyl side-chains of the 'branch' pyrroles with the side-chains of the adjacent pyrroles of the major ring. The model shows these to lie in close proximity.

Reactions analogous to the foregoing have been described[3,18].

A formulation similar to the foregoing but involving only four pyrroles is ruled out because it was not possible to construct a model of a ring with only three pyrroles.

These considerations lead to the prediction that the final ring-closure leading to the porphyrins should occur between rings *A* and *D*. Bonnett *et al.*[19], on the basis of structural considerations, feel that ring closure of the chromophore of vitamin B_{12} must also occur between rings *A* and *D*; the biogenesis of this molecule is certainly similar to that of the porphyrins[19–21].

Robinson[22] suggested that the initial step in the formation of the type III porphyrin is attack by the aminomethyl group of a porphobilinogen molecule (corresponding to ring *D* of the porphyrin) at the $C_{(2)}$ of a second molecule (corresponding to porphyrin ring *A*). The aminomethyl group, initially at $C_{(2)}$, is regarded as migrating to $C_{(5)}$ of the ring. Repetition of the process leads to type III porphyrin, the final ring closure being facile. Bullock *et al.*[23] have put forward an essentially similar idea, but differing in that the initial attack is thought to be by the aminomethyl group of a porphobilinogen molecule destined to form porphyrin ring *A*, on $C_{(2)}$ of a second molecule destined to form ring *D*. These latter authors invoke carbonium ions to explain the migration of the alpha-substituents. Either of these chemically elegant postulations will explain the preferential formation of type III porphyrins, and, in addition, fulfil the requirements for the reaction enumerated above. However, they are not consistent with the known formation of uroporphyrinogen-I from an intermediate in the enzymatic synthesis of uroporphyrinogen III. Further, since the initial, rather than the final, reaction occurs between porphyrin rings *A* and *D*, these postulations cannot provide a facile explanation of the formation of vitamin B_{12}.

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SYNTHESIS OF DIPICOLINIC ACID FROM αε-DIKETOPIMELIC ACID

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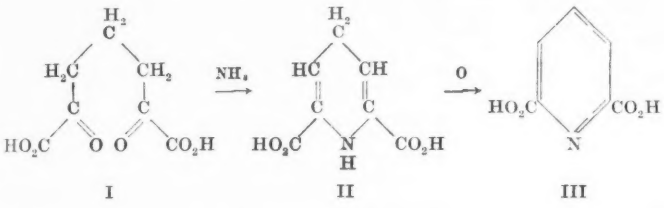
CALCIUM dipicolinate is a constituent of resting spores of *Bacillus* species and is excreted during spore germination[1]. It is not found as a constituent of non-sporulating vegetative cells but is synthesized during spore formation. Vegetative cells and spores of *Bacillus* species contain αε-diaminopimelic acid which, on removal of one amino-group, cyclization and oxidation, would give rise to dipicolinic acid. The L-amino-acid oxidase of *Neurospora crassa* oxidizes *meso* diaminopimelic acid with the production of ammonia equivalent to the removal of one amino-group of the amino-acid[2,3]. The product has no free amino- or keto-groups. Work[3,4] suggests that the α-keto-ε-aminopimelic acid formed may cyclize immediately to form a six-membered ring compound. If this is so, then the product without oxidation could be a reduced form of dipicolinic acid. Evidence of the conversion of diaminopimelic acid to dipicolinic acid in the presence of sporulating cells of *Bacillus cereus* var. *mycoides* was obtained by Perry and

Foster[5], but the efficiency of the reaction was low. In the present work, αε-diketopimelic acid has been investigated as a possible intermediate in the biosynthesis of dipicolinic acid by bacteria. The diketo-acid was prepared by the method of Blaise and Gault[6].

When disintegrated cells of a laboratory strain of *Bacillus cereus* were incubated in air with αε-diketo-pimelic acid, a slow oxidation occurred (Q_{O_2} *c*.1) and there was a decrease in free ammonia as determined by the Conway method. The rate of oxidation was markedly increased (Q_{O_2} *c*.7) by the addition of ammonium chloride. The reaction was allowed to proceed in Warburg flasks in 100 m*M* sodium potassium phosphate buffer, *p*H 7·3, with 10 m*M* diketopimelic acid and 20 m*M* ammonium chloride. The volume of the reaction mixture was 2·5 ml. and each flask also contained 40 mgm. (dry weight) of freshly reaped, washed disintegrated cells from 12-hr. strongly sporulating cultures in potato extract medium[7]. The ultra-violet absorption spectrum of the reaction mixture showed peaks at 2700 and 2775 A., thus resembling dipicolinic acid. It seemed possible that the reaction sequence was as follows:



In these experiments, the production of ultra-violet light-absorbing material was measured, after protein precipitation, by taking difference spectra, that is, the difference in absorbency between reaction mixtures with and without ammonia. The addition of diphosphopyridine nucleotide to the reaction mixtures did not improve the rate of oxidation of the diketo acid. The reaction proceeded with the fixation of 60–80 per cent of the calculated amount of ammonia required for the complete conversion of I to II and the oxygen uptake was roughly 80 per cent of that required for the formation of one double bond, that is, for conversion of II to III. The observed increase in the intensity of the ultra-violet absorption spectrum, however, approached only 50 per cent of that required for the complete conversion of I to III. The highest rates of oxidation of the keto acid occurred in the presence of an ammonium salt as amino donor. Glucosamine, glutamic acid and L-alanine were tested as amino donors: they gave slow and less complete oxidation which was not improved by the addition of pyridoxal phosphate. Glutamine, however, gave higher initial rates of oxidation than did ammonium chloride. The very low Q_{O_2} values obtained for oxidation of diketopimelic acid when no ammonium chloride was added suggested that the oxidizable substrate was, in fact, a reaction product of the keto acid and ammonium ion. The oxidative system was remarkably heat-stable: compared with that obtained with unheated extract, the rate of oxygen uptake was actually increased in the presence of extract previously heated for 10 min. at 100° and centrifuged to remove precipitated material. Assuming this oxidative system is required by living cells to synthesize dipicolinate from αε-diketopimelic acid + ammonium ion it would be expected that such a system and/or the substrate are absent from vegetative non-sporulating cells. When a comparison was made of the oxidative activity of cell homogenates of asporogenous and sporogenous strains of *Bacillus megaterium*, the asporogenous strain was found to give a higher rate of oxygen uptake than the sporogenous strain. In another experiment, disintegrated vegetative cells of *Bacillus cereus* gave a higher rate of oxygen uptake than disintegrated sporulating cells. Finally, an extract of disintegrated cells of *Escherichia coli* was examined and was found to be as active in the system as an extract of disintegrated cells of *Bacillus cereus*.

When a solution of the calcium salt of diketo-pimelic acid and ammonium salt was incubated with buffer, *p*H 7·1, no oxygen uptake occurred. However, ammonia was fixed and an ultra-violet absorption spectrum developed which was similar to but less intense than that obtained under similar conditions in the presence of cell extract. A comparison of the rates of production of ultra-violet absorbing material in the presence and absence of cell extract is shown in Fig. 1. After 4 hr. at 37° C. the yields of product for reactions in the presence and absence of extract were about 44 and 21 per cent of theoretical, respectively, based on the molar extinction coefficient of calcium dipicolinate at 2700 A. Higher yields were obtained if incubation was continued for 24 hr. When the reaction mixture in which ultra-violet absorbing material had been produced in the absence of cell extract was re-incubated with added cell extract, no oxygen uptake occurred. The possibility existed that, in the absence of cell extract, a dihydropyridine-2 : 6-dicarboxylic acid was produced which gave a similar but less intense ultra-violet absorption spectrum than dipicolinate. Isolation of the product was therefore attempted.

αε-Diketopimelic acid (40 mgm.) was dissolved in water (8 ml.) and calcium carbonate (21 mgm.) added to form the neutral calcium salt. An equal volume

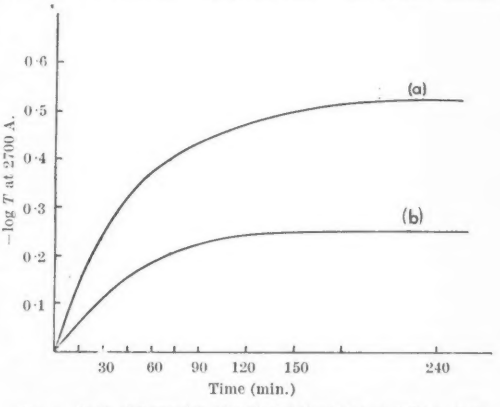


Fig. 1. Rate of formation of material absorbing at 2700 A. from diketopimelic acid and ammonium salt. (*a*) Reaction mixture (2 ml.) contained diketo acid (5 mgm.), calcium carbonate (2·5 mgm.), ammonium acetate (8 mgm.) and heated centrifuged extract from disintegrated vegetative cells of *Bacillus cereus* (20 mgm. dry wt.). Control contained no diketo acid. (*b*) as for (*a*) but without cell extract. Control contained no ammonium acetate. Samples (0·1 ml.) removed at intervals after incubation at 37° C. on a rotary shaker. The absorption of the diluted sample (1 : 30) was measured in a 'Unicam' quartz spectrophotometer (*S.P.* 500) using the appropriate control as blank

of 0·1 *M* ammonium acetate solution was added and the resulting solution (*p*H 7·1) was incubated at 37° C. for 24 hr. The incubated solution was freeze-dried, which removed most of the excess ammonium acetate. The product was dissolved in water (1 ml.) and treated with ethanol (3 ml.). The precipitate was recovered by centrifugation, dried and shaken with a small volume of 0·05 *M* calcium chloride solution. The insoluble fraction was recovered and dissolved in the minimum volume of hot water. On cooling, crystallization occurred. The insoluble material was recrystallized from hot water. The crystals were isolated and dried *in vacuo* at 60° C. over phosphorus pentoxide. Yield approximately 6 mgm. Similar material was isolated from reaction mixtures containing cell extract. In both cases the product was calcium dipicolinate according to the following criteria: (1) appearance of the crystals; (2) extinction coefficients at 2700 and 2775 A.; (3) the infra-red spectra of both products which agreed exactly with that of natural calcium dipicolinate; (4) paper chromatography using Whatman paper (No. 1 or 4) and butanol/acetic acid/water (4 : 1 : 5 v/v, upper phase) as solvent. The spots corresponding to the products and authentic calcium dipicolinate were visible when the dried paper was viewed with a source of ultra-violet light ('Chromalite' lamp) and had the same R_F value. When the paper was sprayed with a solution containing ferrous ammonium sulphate (0·1 per cent w/v) and ascorbic acid (0·1 per cent w/v) in 0·5 *M* acetate buffer, *p*H 5·5 (ref. 8), the spots turned pink.

The formation of dipicolinate in the absence of oxygen uptake can only be explained in terms of an oxidation-reduction reaction occurring between the products of the reaction of diketopimelic acid with ammonia, and perhaps diketopimelic acid. Identification of products other than dipicolinate has not been attempted; but paper chromatography of reaction mixtures showed that a number of compounds is produced. When the effect of oxidizing agents on the reaction was studied it was found that quinone had an effect similar to that of cell extract on the rate of production and final yield of ultra-violet light absorbing product. Fig. 2 shows the rate of production of material absorbing at 2700 A. in the presence and absence of quinone. The absorbency values were affected by the formation of hydroquinone, but increased formation of dipicolinate in the presence of quinone was confirmed by paper chromatography. It is possible that the oxidative system in bacterial cells acts in a similar way to quinone and the reduced system is then oxidized directly or indirectly by atmospheric oxygen.

Attempts to demonstrate diketopimelic acid as a constituent of sporulating cells of *Bacillus cereus* were unsuccessful. In these experiments, deproteinized cell extracts were treated with 2 : 4-dinitrophenylhydrazine and the keto-acid derivatives were extracted with ethyl acetate and chromatographed on paper[9]. Comparison spots of the 2 : 4-dinitrophenylhydrazones of α-ketoglutaric, oxaloacetic, pyruvic and αε-diketopimelic acids and of acetone were run on the same paper. The chromatogram showed derivatives of pyruvic acid and acetone to be present but no diketopimelic acid could be detected in 120 mgm. (dry weight) of cells. However, it was found that when diketopimelic acid was added to cell suspensions which were then disintegrated, treated with reagent and chromatographed, the dinitrophenylhydrazone of this keto acid could not be detected. A negative result was probably due to the rapid reaction of the keto acid with endogenous ammonia when the cells were disrupted.

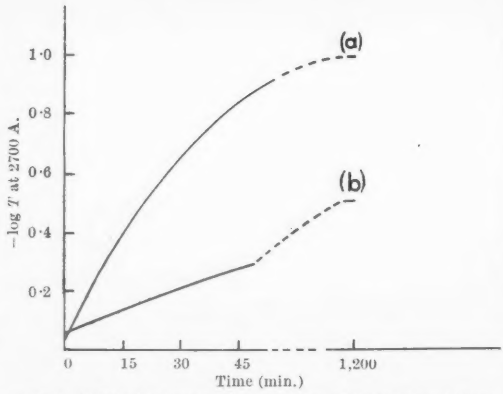


Fig. 2. Effect of quinone on the formation of dipicolinic acid from diketopimelic acid and ammonium salt. (*a*) Reaction mixture (1 ml.) contained diketo acid (2 mgm.), calcium carbonate (1 mgm.), ammonium acetate (4 mgm.) and quinone (0·1 ml. sat. aq. solution). Control solution contained no diketo acid. (*b*) As for (*a*) but without quinone. Solutions incubated at 37° C. and samples treated as in Fig. 1

Attempts to implicate αε-diketopimelic acid as a precursor of αε-diaminopimelic acid in bacterial cells were unsuccessful. Reaction mixtures after incubation of cell homogenate with keto acid and either ammonium chloride, glutamic acid, glutamine or aspartic acid were tested for the presence of diaminopimelic acid using the solvent system of Rhuland *et al.*[10]. Unheated cell homogenates were tested in these experiments and pyridoxal phosphate was added. No diaminopimelic acid was detected in samples of reaction mixture initially containing 130 μgm. of the keto acid.

In an interesting article on the pyridine ring and the problem of its biosynthesis, Grimshaw and Marion[11] have suggested that the pyridine ring might be built directly from smaller units arising from alanine and glycine or possibly from non-nitrogenous precursors and ammonia. Martin and Foster[12] have reported two possible pathways of dipicolinate synthesis in *Bacillus megaterium* involving either pyruvate and aspartate or alanine and oxaloacetate. The experiments reported here are of interest in this connexion, and we consider that even though diketopimelic acid has not been demonstrated as a cell constituent, its reactions with ammonia in the presence and absence of cell extract suggest some interesting possibilities.

We wish to thank Mr. S. Lovett for synthesizing αε-diketopimelic acid and Dr. K. P. Norris for infra-red spectrophotometry. We are grateful to Dr. D. H. Herbert, Mr. E. O. Powell and Major L. H. Kent for useful suggestions and discussion.

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HIGH-RESOLUTION FIBRE OPTICS USING SUB-MICRON MULTIPLE FIBRES

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IN various image transmitting applications of fibre optics[1,2] using the light conduction property of fibres because of total internal reflexions, it is desired that the fibres have a high light transmission, complete optical insulation and diameter as small as possible. The information density in a perfectly insulated fibre bundle is dependent only on the fibre diameter, which has been limited by mechanical properties of the fibres and the basic diffraction phenomenon. This latter limitation, due to diffraction, has not been investigated in the past[3,4], and it had been believed that only fibres larger than 10–20 wave-lengths in diameter are capable of conducting energy. For smaller diameters, it was believed that the energy escapes from the fibre wall due to the diffracted wave striking at angles less than critical incidence.

This is found not to be true for circular cross-section straight fibres down to approximately two wave-lengths in diameter. Fibres as small as 0·75 μ in diameter have been drawn using the newly developed technique of 'multiple fibres', and found to give acceptable light transmission. Whereas diffraction effects occur for fibres of smaller diameter, it has been found that the effective numerical aperture of the emergent diffracted light cone from a straight fibre of diameter greater than two wave-lengths of light is not substantially in excess of the numerical aperture of the lens system required to resolve clearly the fibres at the image pickup end. On the other hand, all the emergent flux is received when a photodetector or photographic plate is placed in contact with the emergent end. Thus high resolution, as well as high light efficiency, is achievable using the more recent techniques in fibre optics.

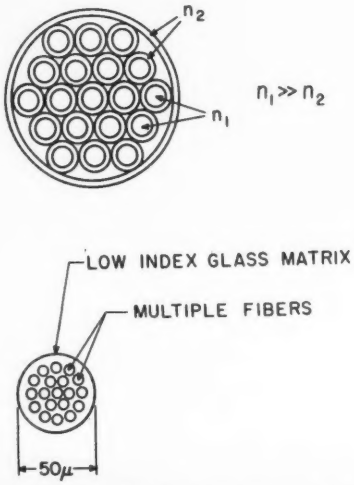

Fig. 1. Illustrating the method of drawing multiple fibres

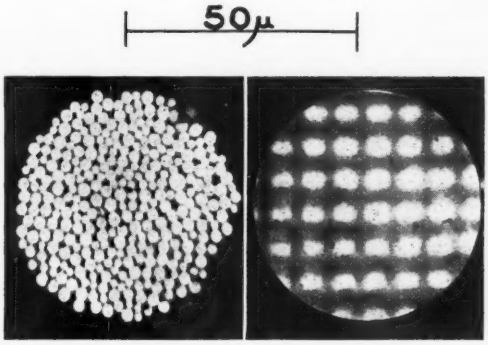

Fig. 2. Photomicrograph of grid object through a 50μ overall diameter multiple fibre consisting of approximately 275 fibres of 2·5μ average diameter

A method for drawing high refractive index fibres coated with a glass of low refractive index consists, essentially, of placing a high-index rod in a low-index tube and pulling the assembly down to a fibre on a continuously rotating drum[5]. Fibres down to 25μ diameter with a coating thickness of 0·5–1μ have been drawn in nominal infinite lengths. In addition to optically insulating the fibre, the coating, also, eliminates surface absorption or scattering losses. A 7-ft.-long glass-coated glass fibre is found to transmit an average of 20 per cent in the visible spectrum and nearly 50 per cent in the yellow-green region. However, such fibres become very difficult to handle mechanically in diameters much smaller than 25μ.

A new type of 'multiple fibre' consisting of a large number of fibres of high refractive index in an insulating matrix of low refractive index has been developed. They have the mechanical strength of large fibres and resolution yield of much smaller fibres. Fig. 1 shows a method for drawing multiple fibres. A large number of high refractive index rods are inserted in low refractive index tubes and the entire bundle is placed in a larger tube of compatible glass. This unit is then drawn into a fibre on a continuously rotating drum. The cross-section of resultant fibres is also illustrated in Fig. 1. The ratio of the parent rod to tube thickness, etc., is maintained in the fibre form. Multiple fibres down to 50μ overall diameter, consisting of as many as 275 fibres of approximately 2·5μ diameter, have been drawn by this method. A high-information density is thus achievable. The mechanical advantages of manipulating and fusing fibres down to a few microns in diameter by this technique are obvious.

Fig. 2 shows a multiple fibre of overall diameter 50μ, with average fibre diameter of 2·5μ. A dynamic picture of a grid test object through this multiple fibre is also shown in Fig. 2. Limiting static resolution of up to 200 lines/mm. has been measured in such an assembly of multiple fibres. As is indicated by further

diffraction studies, the resolution obtained thus far is not the upper limit for the fibre optical systems.

In order to study the optical properties and diffraction effects in smaller fibres, multiple fibres ranging between 0·75 and 20μ in diameter have been drawn. This was achieved simply by choosing parent rods and tubes of different diameters. A multiple fibre was placed on a microscope in which both the numerical apertures of the condenser and the objective could be varied along with the wave-length of light. Fig. 3 illustrates this apparatus diagrammatically. The image of the multiple fibre is formed on a photodetector for the purposes of photometry of fibres of various diameters. Interference filters were introduced in the path; thus different ratios of wave-length of light to fibre diameter are obtained. From elementary considerations, it is clear that due to the diffraction by the fibres, as the objective N.A. is decreased, the photodetector would receive less flux per unit area from fibres of smaller diameters.

Multiple fibres ranging from 0·75μ to 8μ diameter, 0·2 in. long, were thus studied on the above-mentioned system. Two wave-lengths peaked at 386 mμ and 663 mμ with half band-width of 125 A. were used. The condenser numerical aperture was varied from 0·4 to 0·8 and the objective N.A. was varied from 0·3 to 1·33. Within this range of N.A. and wave-lengths, for fibres above 0·75μ diameter, no measurable difference in flux density was observed. For smaller N.A. of the objective, however, one might expect the effects to show up. On the other hand, for such small objective N.A. the fibres fall close to the resolution limit of the system used for image pickup. Fig. 4 shows various diameter multiple fibres that were examined in this manner and a 0·75μ diameter fibre is indicated by an arrow. In Fig. 4*a*, it should be noticed that some fibre separations are of the order of one wave-length, which is the desired thickness, in order to prevent light leakage between neighbouring fibres ($d > \lambda$) due to frustrated total reflexion[5]. Very small quantities of light were observed

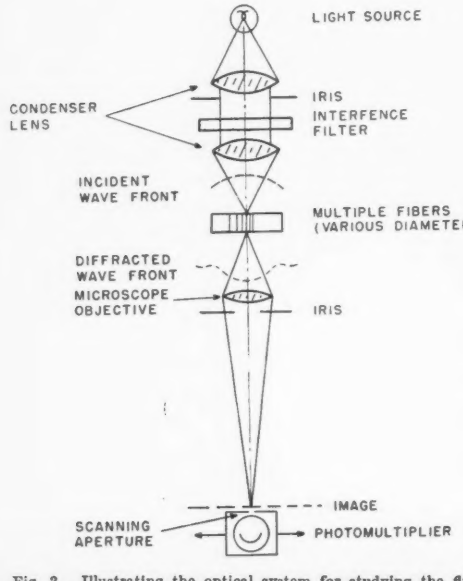

Fig. 3. Illustrating the optical system for studying the flux density in the diffracted wave by multiple fibres of various diameters

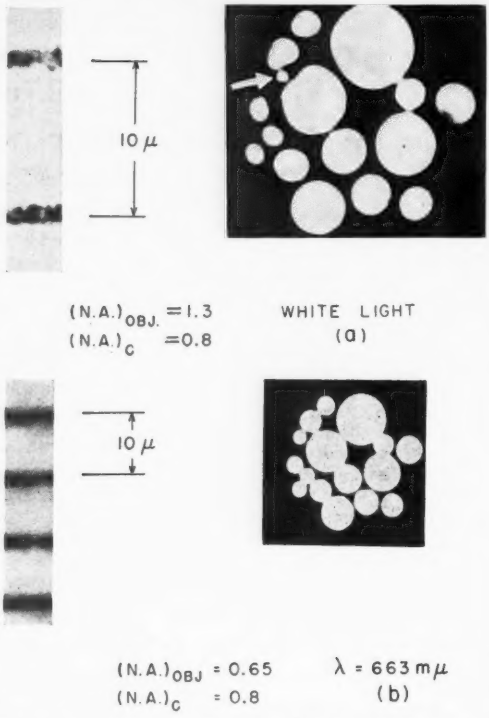

Fig. 4. Photomicrograph of variable diameter multiple fibres (0·75–8μ diameter) obtained on the optical arrangement in Fig. 3. A 0·75μ diameter fibre is pointed out by the arrow

between adjacent fibres. This is attributable primarily to the diffraction effects in the microscope objective and perhaps to a lesser degree to light scattering by the low-index medium that may experience large amounts of stress. In Fig. 4*b* the fibre separation is not observable because the low-index coating falls near the threshold of limiting resolution of the 0·65 N.A. objective. The optical insulation of these fibres was also tested by forming the image of a knife edge and observing the intensity gradient in the transmitted image.

From the results of these experiments, and basic theoretical studies, the following conclusions are derived. To a first approximation, the diffraction in straight circular fibres above two wave-lengths in diameter occur primarily at the two ends. The incoherent wave incident on a fibre suffers diffraction at the entrance dielectric aperture. The diffracted wave then suffers total reflexions and phase changes along its passage in the fibre until it arrives at the emergent end, where it suffers diffraction again. This, of course, assumes that the refractive index of the fibre core and surround is such that the critical angle conditions for the wave in the fibre are satisfied. It is clear that for a plane monochromatic incident wave, as the diameter of the fibre decreases, so the emergent diffracted cone angle increases. On the other hand, as the fibre diameter goes down, so the required N.A. of the optical system receiving the image from the fibres goes up, in order that full use is made of the smaller diameter fibre resolution. For smaller fibres ($d > \lambda$) the limiting resolution of the optical system is set by the fibre coating ($\simeq \lambda$). Thus,

most of the energy emerging from fibres down to 1μ in diameter is received by the appropriate N.A. optical system. These conclusions are also substantiated by a parallel study using microwave analogues of fibre optics at 1·25 cm. wave-length and polystyrene cylinders. Theoretical and experimental studies of diffraction by fibres smaller than the wave-length and the boundary wave skin effect are now in progress.

From the foregoing it is evident that the optical performance of fibres down to a few microns in diameter do not suffer due to diffraction effects. An appropriate assembly of 1μ diameter fibres is capable of a static resolution of 500 lines/mm. and dynamic resolution of nearly 1,000 lines/mm. Fibre optics in the ultra-violet region are capable of even higher resolution. Multiple fibres have rendered such fibre optical systems practical. The impact of these investigations on such applications of fibre optics as flexible endoscopes, field flattener and image transfer from Lambertian emitters is evident. These results are also relevant to some basic studies of the visual mechanism in the retinal rods and cones.

Acknowledgment is due to A. Brushenko and D. F. Capellaro for valuable assistance.

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PALÆOMAGNETIC STUDIES OF CENOZOIC VOLCANIC ROCKS IN NEW ZEALAND

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POSTULATED reversals of the geomagnetic field[1] offer a potential tool for the chronological subdivision and correlation of lavas within a restricted volcanic province[2–4]. On a broader scale they provide potential world-wide datum planes of virtually instantaneous time significance so far as most geological processes are concerned. For reversals to be useful for long-range correlations, not only must their reality be established, but also the length of time between reversals must not be too small in comparison with the time duration of stratigraphically separable stages. An early Pleistocene reversal as postulated by Roche[5], Hospers[6], Einarsson[4] and others should prove to be of considerable importance in Pleistocene chronology if it is established that only one such simultaneous reversal occurred during Pleistocene time. On the other hand, it may be much more difficult to establish contemporaneity of early- or pre-Tertiary reversals. Detailed study of many well-dated suites will be required to demonstrate whether long-range correlation of reversals can be effected, and if so, to determine the date at which each reversal occurred. Data from some New Zealand rocks are here recorded as a contribution towards the solution of these problems. Correlations of New Zealand stages follow the table of Hornibrook[8].

1. *Pleistocene.* Ignimbrite sheets of the Whakamaru district, North Island, New Zealand, are normally magnetized[9]. According to J. Healy (personal communication), they probably belong to the Hawera or late Castlecliffian stage (Upper Pleistocene). Tholeiitic basalt at Timaru overlying gravels of the Waitotaran (Upper Pliocene) to Nukumaruan (Lower Pleistocene) and possibly itself of Nukumaruan age (Gair, H. S., personal communication) is found to have reverse magnetization (north pole directed downwards, dip 75°, declination 228°).

2. *Late Middle to Upper Miocene.* The directions of magnetization have been measured of more than fifty suites of rocks from the Dunedin Volcanic Complex, which has been divided[10] into an Initial, and First, Second and Third Major Eruptive Phases. Each suite consisted of 3–8 (usually 5–6) specimens collected where possible over some tens of yards of exposures in road cuts, quarries and cliff sides. Results from exposed, craggy outcrops are not here considered. Collections were made from sequences of flows in localities scattered over an area of about 12 × 15 miles. The results from each suite have been treated by Fisher's method to obtain the mean directions which are shown in the figures.

Basalts, kaiwekite, phonolites, atlantite and trachyandesites from the First and earlier parts of the Second Major Eruptive Phase all indicate essentially normal magnetization (Fig. 1). In contrast, all flows sampled from the upper part of the middle sub-phase (2 *M*) and the late sub-phase (2 *L*) of the Second Major Eruptive Phase (above flow 21 of the North Head sequence[12]) show reverse or anomalous directions of magnetization (Fig. 2). Basalts, trachyandesites and phonolites are plotted, the basalts being the most consistent. Dotted lines join points representing mean directions of magnetization calculated from two localities in the one

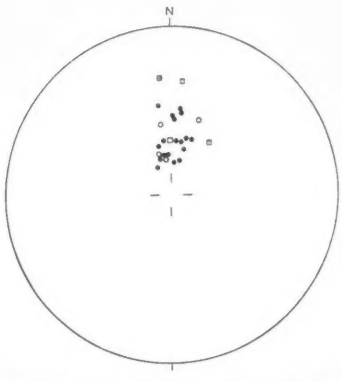

Fig. 1. Directions of magnetization for lavas of First and earlier parts of Second Major Eruptive Phase. Dunedin district, plotted on equal area projection. ●, North pole directed upwards, radius of circle of confidence, 5 per cent level, < 12°; ○, north pole directed upwards, radius of circle of confidence, 5 per cent level, 12–15°; □, direction for symmetrical axial dipole field, latitude 46° S.

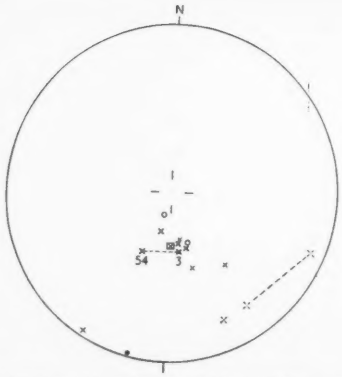

Fig. 2. Directions of magnetization for lavas of the upper-middle and late sub-phases of the Second Major Eruptive Phase, Dunedin district. ✕, North pole directed downwards, radius of circle of confidence, 5 per cent level, < 12°; ×, north pole directed downwards, radius of circle of confidence, 5 per cent level, 12–20°; ✕, north pole directed downwards, radius of circle of confidence, 5 per cent level, > 20°; ●, north pole directed upwards, radius of circle of confidence, 5 per cent level, < 12°; ○, north pole directed upwards, radius of circle of confidence, 12–20°: □, direction for reversed symmetrical axial dipole field, latitude 46° S.

flow (for example, Roslyn doleritic basalt, 3 and 54). The Leith Valley trachyandesite and some similar flows of this period are weakly and erratically magnetized in directions which are consistent only in that they are abnormal. These have not been plotted. We can detect no consistent trend with time for these abnormal directions, and instability is possible, although 'magnetic cleaning' experiments of several types have failed to make them significantly more consistent. Three basalts and two weakly magnetized phonolites of the Third Major Eruptive Phase give normal directions while two other weakly magnetized phonolites correlated with the same period show anomalous declinations (Fig. 3).

There is thus a fairly clear sequence normal—reverse (plus anomalous)—normal in this petrographically diverse volcanic complex. The age of the earlier First Phase volcanics has been established[11] as later Waiauan (latest Middle Miocene) or possibly early Tongaporutuan (earliest Upper Miocene). The upper age limit is not clear although activity probably did not extend far into the Pliocene. If the hypothesis of world-wide contemporaneity of reversals is accepted, a plausible correlation of the reverse period

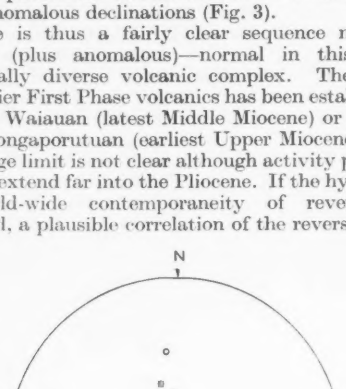

Fig. 3. Directions of magnetization for lavas of the Third Major Eruptive Phase, Dunedin district. Symbols as for Fig. 1

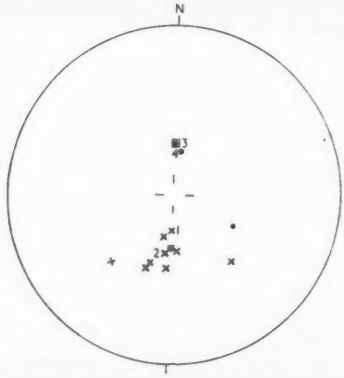

Fig. 4. Directions of magnetization for Upper Eocene–Lower Oligocene volcanics of north-east Otago. Symbols as for Figs. 1 and 2

would be with the Upper Miocene–Lower Pliocene (Pontian–basal Plaisancian) reversal reported in France[3,5], but the possibility that it represents an earlier reversal within Upper Miocene time cannot at present be eliminated.

3. *Eocene–Lowermost Oligocene.* Pillow lava (1), and a dolerite sheet (2) at Oamaru, North Otago, together with a series of dykes and other intrusions of dolerite at Moeraki Peninsula, show reverse magnetization. The results plotted (Fig. 4) have been corrected for post-consolidational tilting. The pillow lava occurs above tuffs correlated with the Kaiatan stage and immediately below tuffs and tuffaceous limestone bands with microfaunas of Kaiatan or Runangan age, that is, earlier or later Upper Eocene (Hornibrook, N. de B., and Marwick, J., personal communication). The Moeraki rocks are also placed in the Kaiatan or Runangan stages on microfaunal evidence (Scott, G. H., personal communication), whereas the Oamaru sheet is Whaingaroan (earlier Lower Oligocene)[12]. A dyke (3) and sheet (4) at Enfield, North Otago, of approximately the same age have normal magnetization.

An Upper Eocene period of reversal is indicated. The evidence does not show whether this continued through to Lower Oligocene times, or whether one or more periods of normal magnetization intervened. The North Otago results are also of interest in that, together with the later Tertiary and Pleistocene results, they do not suggest any measurable polar wandering with respect to New Zealand since Late Eocene times.

We are grateful for the assistance of a number of colleagues. Dr. A. J. R. White has given much help in the field, and a grant to one of us (D. S. C.) from the University of New Zealand Research Fund is gratefully acknowledged.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 9

INSTITUTION OF ELECTRICAL ENGINEERS, ELECTRONICS AND COMMUNICATIONS SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Prof. A. L. Cullen: "Theory of the Travelling-Wave Parametric Amplifier"; Dr. P. J. B. Clarricoats: "The Gain of Travelling-Wave Ferromagnetic Amplifiers"; Mr. A. Jurkus and Mr. P. N. Robson: "Saturation Effects in a Travelling-Wave Parametric Amplifier".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. A. J. Marshall: "Pearl and Cattle Country of the Kimberleys".

Tuesday, November 10

INSTITUTE OF PHYSICS (at 47 Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. F. G. Champion: "Electronic Properties of Diamonds".

ILLUMINATING ENGINEERING SOCIETY (at the Federation of British Industries, Tothill Street, London, S.W.1), at 6 p.m.—Mr. A. H. McKeag: "Research in Phosphors".

Wednesday, November 11

INSTITUTION OF GAS ENGINEERS; BRITISH COKE RESEARCH ASSOCIATION; and the COKE OVEN MANAGERS' ASSOCIATION (in the Lecture Theatre of the Institution of Civil Engineers, Great George Street, London, S.W.1), at 2.30 p.m.—Mr. G. W. Lee: "The First Year of the Coke Research Centre".

INSTITUTION OF MECHANICAL ENGINEERS, LUBRICATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Mr. A. D. Newman: "Extreme Pressure Lubricants for Marine Gears".

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Dr. R. P. Gannon: "Physiological and Acoustical Aspects of Hearing".

OIL AND COLOUR CHEMISTS' ASSOCIATION, LONDON SECTION (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. R. R. Davidson: "Whiting Dispersions, Particle Packing and Surface Adsorption".

Thursday, November 12

INSTITUTE OF METALS, METAL PHYSICS COMMITTEE (at the Royal Institution, 21 Albemarle Street, London, W.1), at 9.30 a.m.—Symposium on "The Application of Thin-Film Techniques to the Electron-microscopic Examination of Metals".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. E. H. S. Burhop: "Transient Forms of Matter".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. J. Davis, Mr. J. S. Greenhow and Mr. J. E. Hall: "Combined Photographic and Radio Echo Observations of Meteors"; and "The Effect of Attachment on Radio Echo Observations of Meteors".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. M. H. F. Wilkins: "The Molecular Structure of Chromosomes".* (Ninth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation. Further lectures on November 17, 19, December 1, 3, 8, 10.)

SOCIETY OF CHEMICAL INDUSTRY, HEAVY ORGANIC CHEMICALS GROUP (at 14 Belgrave Square, London, S.W.1), at 6 p.m.—Mr. D. G. Smith: "The Production of Bulk Organic Chemicals" (Inaugural Lecture).

TEXTILE INSTITUTE (joint meeting with the CLOTHING INSTITUTE, at the British Colour Council, 13 Portman Square, London, W.1), at 6.45 p.m.—Mr. J. David, Dr. T. H. Morton and Mr. W. Garner: "Looking Ahead in the Clothing Industry".

Friday, November 13—Saturday, November 14

INSTITUTE OF PHYSICS, X-RAY ANALYSIS GROUP (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 10 a.m. on Friday and 9.30 a.m. on Saturday—Autumn Conference—"Structure Analysis and Experimental Techniques".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER or LECTURER IN MECHANICAL ENGINEERING—The Registrar, University College, Singleton Park, Swansea (November 7).

HEAD OF THE DEPARTMENT OF APPLIED PHYSICS; HEAD OF THE DEPARTMENT OF MATHEMATICS; HEAD OF THE DEPARTMENT OF AERONAUTICAL ENGINEERING; HEAD OF THE DEPARTMENT OF BUILDING AND CIVIL ENGINEERING—The Registrar, Lanchester College of Technology, Coventry (November 9).

SENIOR LECTURER or LECTURER (with a good honours degree and relevant teaching experience) IN MATHEMATICS at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (November 13).

RESEARCH OFFICER (with a degree in horticulture, agriculture or economics, and preferably a knowledge of horticulture or farm crop production), to carry out investigations into the economics of horticulture—The Secretary, School of Agriculture, The University, Cambridge (November 18).

LECTURER (with good academic qualifications and experience in the field of electric power engineering, preferably electrical machines) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, The University, Leeds 2 (November 20).

RESEARCH OFFICER (honours graduate in engineering or science (or equivalent), with postgraduate experience in the design of radio and electronic equipment) IN THE DIVISION OF RADIOPHYSICS, Commonwealth Scientific and Industrial Research Association, Sydney, N.S.W., Australia, to lead the research of a small group responsible for development and application of new electronics and radio-frequency techniques, particularly in U.H.F. and microwave receivers for use in radio astronomy observations—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 780/199 (November 20).

SENIOR LECTURER, LECTURER, and an ASSISTANT LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, Royal Technical College, Salford (November 21).

ASSISTANT LIBRARIAN IN THE PHILOSOPHICAL LIBRARY—The Secretary, Philosophical Library Committee, The University, Free School Lane, Cambridge, marking envelope "Application" (November 23).

LECTURERS (2) IN PSYCHOLOGY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 30).

PLANT BREEDER (with at least a B.Sc. degree in agriculture or botany and experience in plant breeding or genetics) IN THE SECTION OF PLANT BREEDING AND GENETICS, for duties involving the breeding and selection of sugar-cane varieties—The Director, Mauritius Sugar Industry Research Institute, Réduit, Mauritius (November 30).

SENIOR RESEARCH OFFICER and a RESEARCH OFFICER (qualified zoologists with experience of fisheries research) IN THE DEPARTMENT OF ZOOLOGY, University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, November 30).

RESEARCH FELLOW (with at last two years research experience, and preferably experience in high vacuum techniques or in solid state chemistry) IN THE CHEMISTRY DEPARTMENT, for the study of fundamental processes occurring between lead and reactive gases—The Registrar, University of Melbourne, Carlton, Victoria, Australia (December 4).

PROFESSOR OF APPLIED MATHEMATICS at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or The Registrar, University of Queensland, Brisbane, Queensland, Australia (Australia and London, December 15).

SENIOR LECTURER IN ANTHROPOLOGY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 15).

WAYNFLETE PROFESSOR OF PHYSIOLOGY—The Registrar, University Registry, Oxford (December 17).

TUCKER–PRICE FELLOW FOR RESEARCH IN MATHEMATICS, NATURAL SCIENCES, or an allied subject; and a ROSALIND LADY CARLISLE FELLOW, for research in any other branch of learning—The Secretary, Girton College, Cambridge (January 15).

FISHERIES OFFICER (with a university degree in biology with emphasis on zoology, and experience of fisheries work) in the Northern Region of Nigeria for development of river fisheries and the demonstration and organization of peasant fish culture—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.65/408/01/T.

REPORTS and other PUBLICATIONS

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Great Britain and Ireland

International Union of Pure and Applied Chemistry. A Report on Education and Training in the Paint Industry. Pp. iv+30. Determination of Copper Content of Foodstuffs: Photometric Method. Pp. 4. The Assay of Vitamin A Oils. Pp. 7. The Vitamin A Potency of Beta-Carotene. Pp. 11. A Report on the Vitamin D Bioassay of Oils and Concentrates. Pp. 17. Manual of Physico-Chemical Symbols and Terminology. Pp. iv+27. *7s. 6d.* (London: Butterworths Scientific Publications, 1959.) [109

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Department of Scientific and Industrial Research. Forest Products Research Bulletin No. 38: The Efficiency of Adhesives for Wood. Second edition. Pp. vi+21+8 plates. (London: H.M. Stationery Office, 1959.) *3s.* net. [109

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Guide to Evening Classes in Middlesex, Session 1959–60. Pp. 50+4 plates. (London: Middlesex County Council Education Offices, 1959.) [109

Other Countries

Indian Forest Bulletin No. 207 (New Series). Composite Wood. Wood Waste Utilization. By D. Narayanamurti. Pp. 25. Rs. 1.50; 2s. 3d. Indian Forest Records (New Series). Entomology. Vol. 9, No. 9: Immature Stages of Indian Coleoptera (29) Cerambycidae. By R. N. Mathur. Pp. 176–181+3 plates. Rs. 0.87; 1s. 3d. (Delhi: Manager of Publications, 1957 and 1959.) [109

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LETTERS TO THE EDITORS

ASTROPHYSICS

Observations of the Fine Structure of Enhanced Solar Radio Radiation with a Narrow-Band Spectrum Analyser

THE different components of the solar radio emission at metre wave-lengths were classified according to their spectral properties by Wild and McCready[1] in 1950. In this classification the noise storm or type 1 radiation is characterized by a relatively steady enhancement over a wide range of frequencies, usually with short-lived, narrow-band bursts superposed (storm bursts, type 1 bursts). With equipment of high resolving power, these bursts may be resolved into pips, each lasting for a fraction of a second only.

Observations on single or multiple closely spaced frequencies with high-speed recording facilities have hitherto given valuable information about the pips. At the Solar Observatory at Harestua a double-channel receiver was run during solar noise storms in 1957. The recordings revealed that the very short pips often occured at slightly different times in neighbouring channels[2]. This was then interpreted as being due to a frequency-drift of the pips. Such time differences could not be detected by de Jager and van'T Veer in the 200 Mc./s. range or by de Groot around 400 Mc./s. (ref. 3).

In order to obtain more complete information about the transients, a narrow-band swept receiver has been set up at Harestua. In principle this receiver is a double-conversion superheterodyne. The sweep is performed in the first local oscillator by variable permeability techniques. A frequency-range of 25 Mc./s. from 190 to 215 Mc./s. is swept fifty times per second with a resolution of 0·3 Mc./s. The output is displayed on a cathode-ray tube, with provisions for amplitude and intensity modulation. The screen is continuously recorded on film, and frequency and time-marks are inserted at suitable intervals. The spectrometer is connected to the giant Wurzburg aerial of the Observatory. The sensitivity is uniform over the entire frequency-band.

Some very interesting results have now emerged from the observations. Many pips are found with frequency drifts, and it is important to note that drifts in both directions, that is, to lower or to higher frequencies, are about equally likely. The drift-rate commonly amounts to some 2–5 Mc./s. per sec., but may also well be higher. In some cases, very irregular frequency-drifts exist, whereas at the other extreme the pips may be quite stable. As a rule the half-power band-width of a pip is less than 5 Mc./s. The mean line profile of five radio pips was found to be symmetrical within the limits of error, and was only slightly broader than a Gaussian distribution.

On August 18 a very remarkable fine structure was found in the 200 Mc./s. radiation. This day was characterized by strong optical activity. Interferometer observations gave a position line for the radio source coinciding with a region 30°W. on the northern hemisphere where several flares occurred.

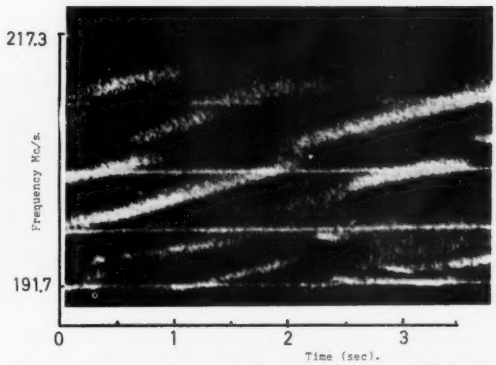

Fig. 1. Narrow-band bursts with regular frequency drift from lower to higher frequencies. (Distance between calibration marks 6·4 Mc./s.).

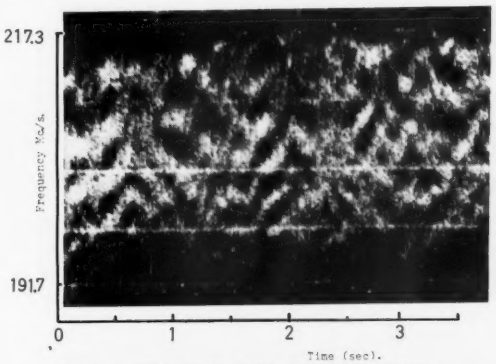

Fig. 2. Complex pattern with drifts in all directions.

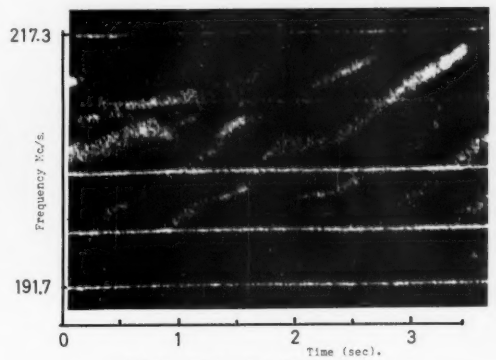

Fig. 3. Burst with possible echo.

The radiation was nearly completely polarized. Between 14h. 28m. U.T. and 14h. 35m. U.T. typical storm bursts appeared on the total power record of the interferometer. On the radio spectrometer, however, these bursts were most interesting. Typical examples are shown in Figs. 1, 2 and 3. On Fig. 1

bursts are seen which have a band-width of about 2 Mc./s. and a sharp cut-off at the low-frequency side. The duration as measured on a single frequency is less than a second, whereas the total life-time amounts to 2–3 sec. All bursts show a regular frequency drift from lower to higher frequencies at a rate of approximately 2–4 Mc./s. per sec. In Fig. 2 the general pattern is complicated, with a most irregular drift, but some kind of order exists, as simultaneous bursts on different frequencies appear to have similar frequency – time paths. Examples of probable echo effects were also recorded. One of them is reproduced in Fig. 3.

There is good reason for believing that the recorded bursts are of solar origin. They are definitely not generated in the receiver, nor, at the present moment, can I see how such effects can be produced by terrestial interference or exceptional ionospheric conditions.

These preliminary observations show that the phenomenon of frequency drift is not confined to the type 2 and type 3 emissions, but is also found in the fine structure of type 1 radiation, although here on a smaller scale. The storm bursts are probably more complicated than has been supposed, but as the wide-band radio spectrographs have been powerful tools in the investigation of the large-scale structure of the solar radio emission, there is reason for believing that high-resolution spectrometry would give a most valuable insight into the fine structure of the storm phenomena.

The results of a more detailed investigation of the spectrograph records will be published elsewhere.

My thanks are due to Mr. G. Eriksen for assistance with the equipment. The investigation is being sponsored in part by the U.S. Air Force (ARDC, European Office).

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Evidence for Cosmic Ray Energy Spectrum Changes During a Forbush Decrease

The multiplicity of neutron production in a conventional neutron monitor, though not a rapidly varying function of incident particle energy, might be expected to be determined by the spectrum of incident particles. During the Forbush decrease which started on May 10, and for a considerable period previously, one half of the Sydney neutron monitor was connected to a scaler with a paralysis time of 500μ sec. as well as to the conventional recorder. The purpose of the second scaler is to study changes in multiplicity, and its operation is as follows.

A single interaction in the lead of the monitor structure often produces more than one neutron, so that the normal recording system, which has a resolving time of a few μ sec., can record several counts for a single incident particle. The lifetime of the neutrons in the structure is about 150μ sec., so the long paralysis time of the second scaler effectively ensures that it will record only one count per incident particle. Thus the difference between the readings of the two scalers for the same time-interval gives a measure of the number of 'multiple' neutrons produced, and the ratio of this quantity to the rate of the scaler with the long paralysis time is related to the average multiplicity.

In particular, let N_1 be the daily count of the scaler with short paralysis time, and N_2 that of the other. To search for multiplicity effects we have examined the variation of the quantity:

$$m = \frac{N_1 - N_2}{N_2}$$

The values of N_1 and N_2 on a typical day are 300,000 counts and 250,000 counts, and the value of m is 0·2.

Taking the period April 1–May 6, 1959, and deriving the standard deviation from the actual scatter in values:

$$m_1 = 0{\cdot}1980 \pm 0{\cdot}001.$$

During the period of the decrease, that is to say from May 7 to approximately May 31:

$$m_2 = 0{\cdot}2085 \pm 0{\cdot}0006.$$

and even from June 1 to July 5,

$$m_3 = 0{\cdot}2013 \pm 0{\cdot}0007.$$

The daily values and the monitor counting rate are shown in Fig. 1. Corrections to these values of m for the dead times of the scalers, and the detection of multiple neutrons after 500 μ sec. are small and relatively constant. It seems likely that the interactions in the monitor during the period of the decrease in rate were of higher than average multiplicity, which corresponds to an increased proportion of incident particles of high energy.

The Sydney group is operating an underground spectrometer, located in a tunnel under about 60 m. water equivalent of rock. Statistics are not good; but no change in rate greater than a few per cent occurred during this period. The spectrometer was operating at zero field at the time, and the minimum energy detected was about 13 GeV.

We are thus drawn to conclude that the mechanism of this decrease was such that the rate was lowered by removing particles from the low-energy end of the cosmic-ray spectrum, which agrees with work on the dependence on latitude of Forbush decreases. In view of the interest shown in the mechanism of the Forbush decrease it would seem to be worth while to attach a second scaler with a long paralysis time to

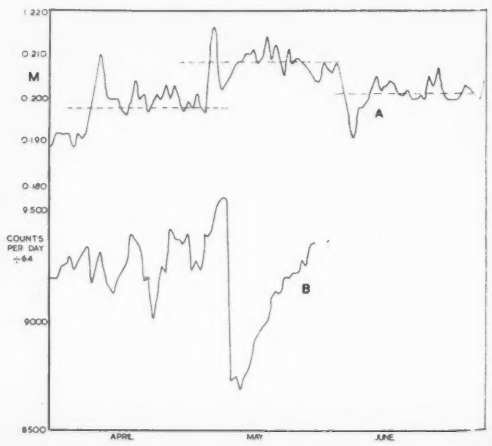

Fig. 1.

other monitors to confirm this observation. A circuit responding only to events with recorded multiplicity greater than two or three could be used also, and might give a larger effect. One cannot however expect a rapid variation of m with energy, especially since the monitor is designed to maximize the rate by the use of a thick lead neutron producer.

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GEOPHYSICS

Diurnal Variation of Aurora and Geomagnetic Disturbance at New Zealand Antarctic Stations

The diurnal variation of auroral incidence for Scott Base (New Zealand) and Hallett Station (United States–New Zealand) during the International Geophysical Year is shown in Fig. 1*A*. Curves derived from analyses of concurrent visual and all-sky camera observations are shown separately. The visual curves are based on observations during all hours which have $\frac{3}{8}$ or less cloud cover and the all-sky camera curves on photographs in which the Southern Cross is visible (exposures: Scott Base 20 sec., Hallett Station 15 sec., on Tri-*X* film). The auroral frequencies were computed from quarter-hourly data except Hallett Station visual for which virtually continuous observations were used. This higher density and also the greater sensitivity of the visual observations at Hallett Station for displays near the horizon and in the presence of moonlight, twilight, and thin cloud lift the Hallett visual frequencies well above the photographic frequencies. The Scott Base visual curve is indistinguishable from the one obtained at Cape Evans during 1911, a period of sunspot minimum, by the British (*Terra Nova*) Antarctic Expedition[1].

The diurnal variations of auroral frequency for the two stations are very similar in form and characterized by primary morning and secondary evening maxima. Such bi-modal frequency curves have been derived before and have been the subject of comment by Hulbert[2], who, however, failed to ascribe any significance to them. Obvious considerations make it impossible to obtain full diurnal curves except at very high latitudes and this has retarded the study of the diurnal variation of auroral incidence, a subject which must have considerable bearing on the theories of auroræ.

On the other hand geomagnetic disturbance can be studied for the full day at all latitudes. Following the 1932–33 International Polar Year, an analysis of the irregular magnetic disturbance D at ten high-latitude stations led Stagg[3] to postulate three zones with different characteristics in the diurnal variation of D. The outer zone ($\varphi_m < 70°$) is primarily governed by a 24-hr. wave with the maximum in the evening, the maximum occurring at midnight at $\varphi_m = 70°$. For $\varphi_m > 78°$ the daily variation in D has again one dominant maximum but this is invariably in the forenoon. The transitional zone ($\varphi_m = 70°$ to $\varphi_m = 78°$) has a daily variation in D marked by two maxima, one in the morning and the other in the evening.

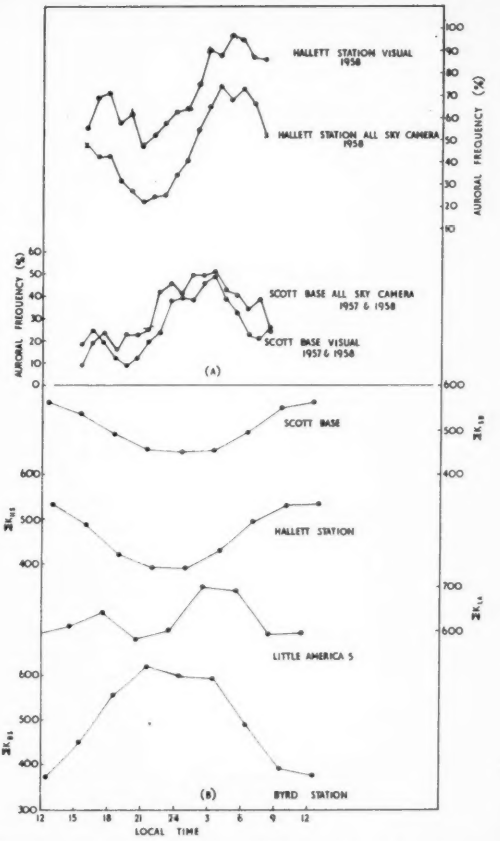

Fig. 1. *A*. Diurnal variation of auroral frequency, Scott Base (mean of 1957 and 1958) and Hallett Station 1958. Visual and photographic data shown separately. × indicates sample less than 30.
B. Diurnal variation of magnetic disturbance at several Antarctic stations for months March to September 1958 inclusive.

K indices measured during the International Geophysical Year have been used to derive the daily variations of magnetic disturbance at Scott Base and Hallett Station, and at two other stations, Byrd Station and Little America 5. The co-ordinates of the stations are shown in Table 1.

Table 1. Co-ordinates of Antarctic Stations used in Magnetic Disturbance Analysis

Station	Latitude		Magnetic Dip
	Geographical	Geomagnetic	
Byrd Station	80·0°S.	−70·6°	Approx. −75°
Little America 5	78·2°S.	−74·0°	−79·9°
Hallett Station	72·3°S.	−74·7°	−84·8°
Scott Base	77·8°S.	−79·0°	−82·0°

K indices from these Stations for each 3-hr. period have been summed for the auroral months March–September 1958 inclusive. The diurnal variation of ΣK for each station is shown in Fig. 1*B*. According to Stagg's classification, Byrd Station is in the outer zone; Little America 5 is in the transition zone; and Scott Base and Hallett Station are in the inner zone although Hallett Station and Little America are of similar geomagnetic latitude. Their dips, however, are dissimilar.

The diurnal variations of auroral incidence and local geomagnetic disturbance at Scott Base and

Fig. 2. Change in auroral probability with increase in local geomagnetic disturbance, Scott Base and Hallett Station. The last point on each of the Scott Base curves (joined by the longer-dashed line) has a sample of less than 30.

Hallett Station appear to have no simple relationship. The probability of occurrence of auroræ during an hour which is part of a three hourly interval of any K index is shown for Scott Base and Hallett Station in Fig. 2. At Scott Base auroral probability increases only slightly with K index until conditions become stormy, whereas at Hallett Station there is a marked increase in auroral probability with increase in geomagnetic disturbance. A computation of diurnal auroral occurrence from Fig. 2 and the frequency spectrum of K indices at each 3-hr. interval gives single maximum curves with less than 10 per cent diurnal variation in probability. Thus, although there is a relationship between aurora and geomagnetic disturbance the main features of the diurnal variation curves are caused by events unrelated to local geomagnetic disturbance. On the other hand the principal maximum, secondary maximum and the minimum of geomagnetic disturbance at Little America 5 appear to be almost coincident with similar auroral events at Scott Base and Hallett Station.

An interesting difference occurs between the diurnal character of magnetic disturbance at Little America 1 (1929–30) and that reported above for Little America 5 from recent K indices. Davies[4] found that at all seasons during 1929–30 the magnetic disturbance curve was of the single-maximum outer zone type, the maximum being at 03·5 hr. local time. This is approximately the time of the primary maximum in the 1958 observations but the quite well developed secondary maximum of 1958 is absent from the earlier observations. It should be stated that Little America 5 (Kainan Bay) is about 50 miles east of Little America 1 (Bay of Whales) and the geomagnetic latitude of Little America 5 is less than that of Little America 1. It should also be noted that the magnetic dip has decreased from −82° 20′ at Little America 1 in 1929 to −79° 56′ at Little America 5 in 1958. Sunspot numbers in 1929 were lower than 1958 although 1928 was the maximum year of the cycle.

Comparison of auroral incidence obtained by visual and photographic methods is of some interest apart from the main themes discussed in this letter for it is highly probable that most future auroral studies will be made photographically and it is necessary to decide whether the large body of visual data gathered in the past can be used together with that derived by photographic techniques. The intensive observations made at Scott Base and Hallett Station during the International Geophysical Year enable the methods to be compared for frequency studies and Fig. 1*A* shows clearly that visual methods provide results comparable in this respect with photographic studies.

We are indebted to the Director, U.S. Coast and Geodetic Survey for providing K indices for Little America and Byrd Stations.

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Exchange Interaction as a Cause of Reverse Thermo-Remanent Magnetism

We reported, in 1952, the occurrence of self-reversing thermo-remanent magnetism of the ferromagnetic minerals contained in the hypersthene hornblende dacite pumice of Mount Haruna, Japan[1]. The physical mechanism producing this particular phenomenon was at first considered to be one postulated by Néel[2], that is, a magneto-static interaction during field-cooling, between two ferromagnetic phases (A and B) with different Curie points (T_{cA} and T_{cB}). We ascertained that the ferromagnetic minerals consist of two distinct phases, A being a cubic titanium-poor titanomagnetite ($T_{cA} \sim 500°$ C.) and B a rhombohedral solid solution between ilmenite and hæmatite 0·55 $FeTiO_3$.0·45 Fe_2O_3 ($T_{cB} \sim 200°$ C.)[3]. The abundance ratio of A and B was found to be A/B about 0·02. Subsequent investigations have revealed that the ilmenite-hæmatite phase is the only constituent responsible for our reverse thermo-remanent magnetism; the titanomagnetite phase, although more abundant, is irrelevant to the phenomenon[4].

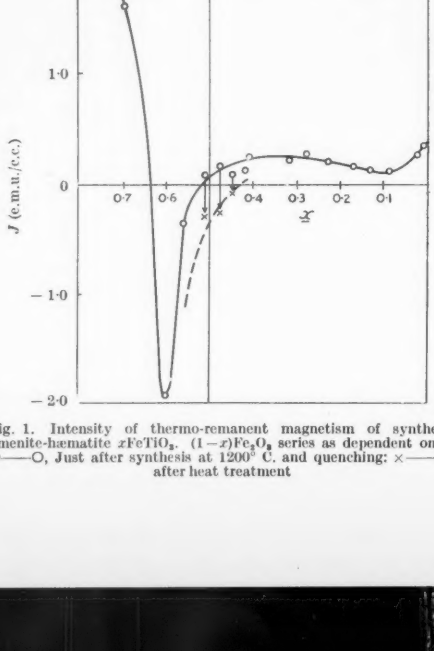

Fig. 1. Intensity of thermo-remanent magnetism of synthetic ilmenite-hæmatite $x FeTiO_3$. $(1-x)Fe_2O_3$ series as dependent on x. O——O, Just after synthesis at 1200° C. and quenching: ×——×, after heat treatment

Recently, evidence has been obtained showing that this property of reverse thermo-remanent magnetism is intrinsic to the ilmenite-hæmatite series and that the mechanism causing it should be of the nature of the exchange interaction. Fig. 1 shows the intensity of the total thermo-remanent magnetism produced by cooling from above the Curie point in a magnetic field of 2·0 oersteds, of a series of synthetic ilmenite-hæmatite solutions, $x\mathrm{FeTiO_3}.(1-x)\mathrm{Fe_2O_3}$, the abscissa denoting the value of x in the chemical formula. It is observed that the reversal of the polarity takes place within a restricted range of x, namely, $0{\cdot}45 \leqq x \leqq 0{\cdot}6$. The members having $0{\cdot}45 \leqq x \leqq 0{\cdot}5$ show only normal thermo-remanent magnetism just after the synthesis at 1200° C. followed by quenching, but can acquire the reverse thermo-remanent magnetism property after an appropriate heat-treatment.

The magnetic properties of the ilmenite-hæmatite series are known to be complex[5]. At room temperature, the series is divided into the following three regions, namely, the paramagnetic region for $1 \geqq x \geqq 0{\cdot}8$; the ferrimagnetic region for $0{\cdot}8 \geqq x \geqq 0{\cdot}45$ and the antiferromagnetic region for $0{\cdot}45 \geqq x \geqq 0$. In the last region, so-called parasitic ferromagnetism of the hæmatite-type is superimposed. This complicated nature of the magnetic property of the $x\mathrm{FeTiO_3}.(1-x)\mathrm{Fe_2O_3}$ series has been interpreted in terms of an order-disorder phenomenon among the iron and titanium ions in the lattice[6]; an ordered state of $R3$ symmetry is realized in the ferrimagnetic region, whereas the disordered state of $R3C$ symmetry prevails in the antiferromagnetic region. In support of this, it was also shown that the magnetic properties are extremely sensitive to heat-treatment for the members with x about 0·5, that is, near the border between ferrimagnetic and antiferromagnetic regions[7]. Taking the above-quoted general magnetic properties of the series into consideration, it may safely be said that the results in Fig. 1 show that the ability to produce the reverse thermo-remanent magnetism is peculiar to those members of the ilmenite-hæmatite series which belong to the border region between the ferrimagnetic and the antiferromagnetic regions, and the true mechanism of the reverse thermo-remanent magnetism should be closely related to the same order-disorder phenomenon as that which causes the ferrimagnetic ⇌ antiferromagnetic transformation.

Whatever the detailed mechanism may be, it is possible to express the effective magnetic field that should be responsible for the production of the reverse thermo-remanent magnetism as $H_{\mathrm{eff}} = H_{\mathrm{ex}} - H_{\mathrm{int}}$, where the suffixes stand for effective, external and interaction respectively: $H_{\mathrm{eff}} > 0$ and $H_{\mathrm{eff}} < 0$ correspond to the cases of normal and reverse thermo-remanent magnetism. Therefore, the dependence of the intensity of thermo-remanent magnetism on H_{ex} will give a lower limit value of the interaction field H_{int} at the value of H_{ex} where the thermo-remanent magnetism becomes zero. The reason for the lower limit is that the other ferromagnetic constituents, like the A component in the Haruna specimen, will favour the normal thermo-remanent magnetism. In Fig. 2, the curves (*a*), (*b*) and (*c*) show the intensity of thermo-remanent magnetism versus H_{ex} for the original Haruna ferromagnetic minerals $(A + B)$, the Haruna ferromagnetic ilmenite-hæmatite (B) minerals after separation from titanomagnetite (A), and the synthetic specimen $0{\cdot}48\,\mathrm{FeTiO_3}.0{\cdot}52\,\mathrm{Fe_2O_3}$, respectively. In the former two cases, the condition $H_{\mathrm{eff}} = 0$ gives the magnitude of the apparent H_{int} as

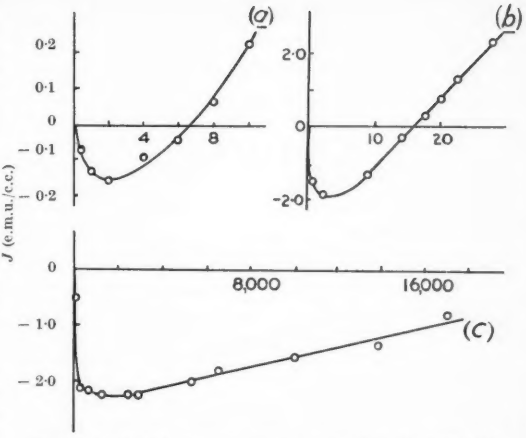

Fig. 2. (*a*) Partial thermo-remanent magnetism J (250°–350°) versus H_{ex} (oersteds) of Haruna ferromagnetic minerals $(A + B)$. (*b*) Total thermo-remanent magnetism J (20°–350°) versus H_{ex} (oersteds) of Haruna ilmenite-hæmatite B. (*c*) Total thermo-remanent magnetism J (20°–400°) versus H_{ex} (oersteds) of synthetic ilmenite-hæmatite $0{\cdot}48\,\mathrm{FeTiO_3}$. $0{\cdot}52\,\mathrm{Fe_2O_3}$

about 7 and 15 oersteds, and in the last case it gives a value greater than $1{\cdot}6 \times 10^4$ oersteds. Although the former two values can be explained in terms of magneto-static interaction[4] it would be evident that the last figure can never be accounted for by any magneto-static interaction.

It may well be mentioned that the careful study of the thermal variation of the saturation magnetization gave no indication that the specimen concerned had Néel's N-type characteristics[2]. Excluding the possibility of the N-type ferrimagnetics, the only possible source of such an intense interaction seems to be the exchange interaction across the boundary between two connected phases. This possibility has been mentioned by Néel[8] and Gorter[9] recently. Actual examples of the exchange interaction across the boundary between separate phases have been reported by Meiklejohn and Bean as a cause of the extremely strong magnetic anisotropy of Co-CoO, Fe-FeO and $\mathrm{Fe\text{-}Fe_3O_4}$ systems[10]. In our case the participating phases are both considered to be in the ilmenite-hæmatite series and the order-disorder phenomenon is the possible source for the distinction of the two phases. A fuller account of the present study will be seen elsewhere[11]. The detailed nature of the exchange interaction concerned is under investigation.

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PHYSICS

A Comparison of the Charges of the Electron, Proton and Neutron

It has recently been suggested by Bondi and Lyttleton[1,2] that the magnitudes of the electric charges on the proton and electron may differ by a little more than one part in 10^{18}, in which case electrostatic forces would cause the universe to expand. In fact, Piccard and Kessler[3] attempted to detect such a difference in 1925, and found that a molecule of carbon dioxide did not have an electric charge greater than $2\times10^{-19}e$, where $-e$ is the electronic charge, from which they concluded that the magnitudes of the proton and electron charges were the same to within 5 parts in 10^{21}, assuming that matter was built entirely of protons and electrons. Since matter also contains neutrons, they have assumed in effect that the neutron has a charge equal to that of a hydrogen atom; but the neutron might equally well have a charge opposite to that of a hydrogen atom, in which case their experiment does not settle the point at issue, since carbon dioxide contains equal numbers of protons and neutrons (to within 0·1 per cent). It therefore seemed desirable to find whether matter in which there is an excess of neutrons is electrically neutral. We have found that the charge on an argon atom (18 protons, 18 electrons and 22 neutrons) is not greater than $8\times10^{-20}e$ and that on a nitrogen molecule (14 protons, 14 electrons and 14 neutrons) is not greater than $12\times10^{-20}e$. Treating the charges on nitrogen and argon as the sums of charges on protons, electrons and neutrons, it is deduced that the proton charge is $(1\pm4\times10^{-20})e$ and the charge on the neutron is less than $4\times10^{-20}e$.

As in the earlier experiment, the method used was to attempt to detect a charge on a large volume of de-ionized gas by detecting a change of potential of a vessel from which the gas was allowed to escape. Fig. 1 is a diagram of the apparatus. A cylinder of compressed gas was placed inside an aluminium box A which was itself placed inside, but well insulated from, a larger aluminium box, B. A vibrating-reed electrometer (type 1086C) was used to observe changes in potential of box A relative to B when gas was transferred from inside the inner box to a gasometer outside the system, the gas flow being controlled by a clip on the gasometer inlet tube. Before leaving the inner box, the gas passed through the 1·2-mm. gap between two coaxal cylinders held at 45 V. potential difference to remove ions from the gas. (The time taken for an ion of normal molecular mobility to drift across the gap would be $1\cdot2\times10^{-4}$ sec., whereas the gas spends at least 5×10^{-3} sec. in the ion trap at the rates of flow used.) Care was taken that although the copper outlet tube (H) was well insulated from the inner box, the gas did not flow directly over any insulators after leaving the ion trap, before passing out of the system.

The large ionization current in the air between the boxes was backed off by applying a potential of about 0·25 V. between them before making the measurements, but convection currents which started when the expanding gas cooled the tubes caused fluctuations in the current. These effects were considerably reduced by using double-walled tubes containing thermal insulation.

On starting and stopping the flow of gas, there were sudden changes of potential, which depended only on the rate of flow, and not on the duration. These were presumably due to mechanical movements when the pressure changed, through capacitative effects of the applied potential differences and contact potential differences.

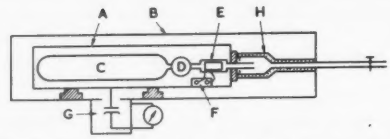

Fig. 1. C, Gas cylinder; D, reducing valve; E, ion trap; F, battery; G, electrometer; H, double-walled outlet tube containing thermal insulation; hatched areas, polystyrene insulators.

Fig. 2a shows the mean of 19 sets of observations with argon, with the potential changes converted into charge on the inner box. The charge on the box is plotted at 5-sec. intervals from K to L, when the gas flow was started. The readings were continued during a steady release of gas (L' to M') and after the flow of gas was stopped (M to N). Since the potential jumps on starting and stopping the flow of gas were unequal (due to a charge apparently carried by the first 30 c.c. of gas) the results are replotted (Fig. 2b) with the jumps LL' and MM' subtracted. As the trend of the points from L to M is not significantly different from the rest, the gas can have carried no significant amount of charge. To obtain a quantitative result, an attempt is made to extrapolate the readings KL and NM (dashed lines), with the result that the charge carried away by 81 litres of argon (at N.T.P.) is estimated as $(+1\cdot5\pm1\cdot5)\times10^{-14}$ coulomb, corresponding to a charge of $(4\pm4)\times10^{-20}e$ per atom of argon. When no field was applied in the ion trap, a charge of $(+5\cdot5\pm2)\times10^{-16}$ coulomb per litre was carried away under the same conditions, corresponding to an excess of 3 positive ions per cm.^{3}, but this varied considerably with gas pressure and rate of flow. (This result is not unreasonable, taking account of initial recombination in the high-pressure gas, and removal of ions by thermal diffusion in the trap.) With nitrogen the mean result of 5 runs was that 58 litres carried $(+1\cdot5\pm1\cdot5)\times10^{-14}$ coulomb, corresponding to $(6\pm6)\times10^{-20}e$ per molecule. It is hence deduced that the neutron charge is $(-1\pm3)\times10^{-20}e$ and the hydrogen-atom charge is $(1\pm3)\times10^{-20}e$.

The ion trap would not remove charges carried by sufficiently large particles; but it is unlikely that such charges have neutralized a bulk charge of the gas, as any space-charge equilibrium set up in the cylinder would be governed by thermal diffusion and

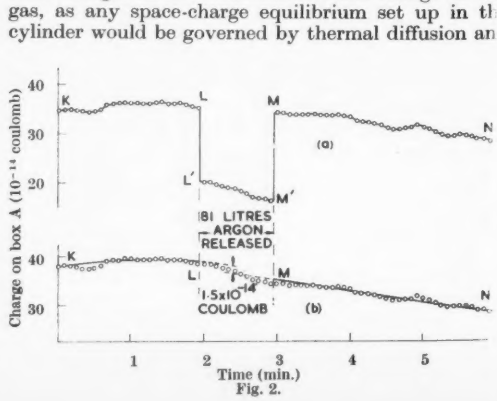

Fig. 2.

drift of the small ions, which are later removed by the ion trap. The same results were obtained with several different gas cylinders and also with 300 V. applied in the ion trap. The charge calibration was checked using a 10^{13}-ohm resistor connected to box *A*.

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Aug. 30.

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Decay of a Tau-Meson Underground

THE decay of heavy cosmic ray particles underground has been reported by Higashi *et al.*[1], and L. and M. Avan[1]. Higashi found a neutral *V*-particle in a multiplate cloud chamber at a depth of 40 metres water equivalent underground. The *V*-particle was produced by a shower secondary from a large interaction in the chamber. Avan, using glass-backed emulsions at a depth of 300 metres water equivalent, reported the decay of two *K*-mesons, one of which was produced in the glass backing of an emulsion.

Support of an unambiguous nature is given here to the foregoing evidence on *K*-meson decay underground in that the easily recognizable tau mode of decay has been observed in favourable conditions. The tau-meson decayed at rest in Ilford *G*.5 emulsions of thickness 400 microns. The emulsions formed part of a stack of 24 strips of major dimensions 10×10 cm. which were manufactured, exposed, and developed at a depth of 57 metres water equivalent underground in Holborn tube station (London). During the exposure of 97 days the emulsion strips were interleaved with thin sheets of tissue paper with their planes vertical, and were packed in an air-tight container surrounded by 15 cm. of lead.

The tau-meson was found among 134 μ-mesons, 97 ρ-mesons, 17 σ-mesons, $5\pi^+$-mesons, 10 neutron stars and 9 stars with charged primaries, in a scan covering 38 c.c. of emulsion. Of the σ-mesons, two were associated with more than one interaction proton of residual range greater than 10μ, and seven had only one or more short interaction tracks, of residual range less than 5μ, such as are characteristic of slow μ^--meson interactions. Two of the π^+-mesons were decay particles of the tau-meson. All the stars included above had three or more heavily ionizing tracks, of which at least one had a residual range greater than 100μ. There were 12 other stars in the scanned volume which did not satisfy the above criteria. Four of these were of the $1+1P$ type which have been interpreted as due to giant resonance interactions of μ-mesons[2].

The tau-meson entered the stack moving downwards at an angle of 60° to the vertical and stopped in the stack after covering a range of 4·7 mm. According to the range-energy tables of the Göttingen group[3], which were also used in calculating energies in Table 1, this corresponds to a kinetic energy on entry of $25{\cdot}9 \pm 0{\cdot}3$ MeV. The tau-meson was identified by its characteristic decay scheme and by the results of gap counting which indicated a singly charged particle of mass $1000 \pm 200\, m_e$. Decay at rest was confirmed by observations on the decay π-mesons (see Table 1) which were coplanar to within 2°, and showed momentum balance at the point of decay within 5 per cent along and perpendicular to the direction of decay particle No. 1.

Table 1. THE DECAY PARTICLES

Particle No.	Nature	General	Residual range (mm.)	Energy at decay point (MeV.)	*Q* value of decay (MeV.)
1	π^+	Decay at end of range $\pi^+ \rightarrow \mu^+ \rightarrow e^+$	29·9	$43{\cdot}0 \pm 0{\cdot}1$	
2	π^+	,,	4·4	$14{\cdot}5 \pm 0{\cdot}3$	$70{\cdot}6 \pm 0{\cdot}7$
3	π^-	Interaction at end of range. Single ($9{\cdot}3 \pm 0{\cdot}4$) MeV. proton emitted	3·7	$13{\cdot}1 \pm 0{\cdot}3$	

Of the decay particles, only No. 3 stops outside the scanned volume.

Errors in the energies given are based on the statistical distribution of mean ranges[4]. They do not allow for systematic errors due to such factors as track losses in the interleaving tissue paper between emulsion strips, in erosion and anomalous development at emulsion surfaces, or any difference in density which may exist between the emulsions used here and those on which the Göttingen tables are based. However, from observations on the five μ^+-mesons from the decay of π^+-mesons in the stack, two of which passed from one emulsion strip to another, it would appear that any systematic errors included in the results are small, and may lead at most to an underestimation of the *Q* value of about 2 or 3 per cent. Hence the best mass value for the tau-meson based on the *Q* value and the masses of the decay particles is $(958^{+6}_{-2})m_e$, and agrees with the accepted value of $(966{\cdot}8 \pm 0{\cdot}4)m_e$[5]. In view of the above observations it may be taken that the decay of a heavy meson has been established.

The tau mode of decay is rare and occurs with a frequency of about 1:14 among K^+-meson decays. This ratio appears to apply whether production is by charged particles or by photons[6]. Hence where the tau mode is observed, it is likely that the other modes also occur. Of the other decay modes, the $K\mu_2$, $K\pi_2$ and K_{e3}, which together account for some 86 per cent of K^+-meson decays[7], resemble μ-meson decay or $1+Op$ stars in that they are associated with a relativistic decay particle whose ionization is near the plateau value. These would be difficult to identify without extensive measurements in emulsions exposed underground, as the rates of particles stopping are small even for long exposures; fading of the latent track image occurs, and a high background density has to be overcome[8]. Further, all the extensive emulsion exposures underground by other workers have so far been made with emulsions mounted on glass plates. As the glass plates restrict measurements on any event to the narrow emulsion strip in which it is found, it is not surprising that only two K^+-mesons have been reported hitherto.

If direct production of *K*-mesons by μ-mesons is assumed, then the cross-section for the process should be given by the Williams-Weizsäcker method as used by George[9]. The method associates a virtual photon spectrum with relativistic μ-mesons, and their cross-section for nuclear interactions is given by the product of the virtual photon spectrum and the cross-section of real photons for the process considered. There are two major obstacles which prevent such a calculation here. The first of these involves uncertainties in the validity of the method for energy transfers greater than 500MeV. at μ-meson energies above 10GeV.[1],

while the second concerns the paucity of the data on heavy meson production by real photons. However, the limited data which are available on the interactions of 1 GeV. photons are encouraging in that heavy mesons[10] and multiple π-mesons[11,12] are produced. This would seem to indicate that the W-W method may be used to interpret the showers induced underground by μ-mesons. If this is the case, then photon interaction processes such as the production of K-mesons and hyperons should occur.

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Ratio of Nucleon Mass and Electron Mass

In classical physics, the value of the fine structure constant $\varepsilon^2/\hbar c$ is 1/137. The value of the pion-nucleon interaction constant $g^2/\hbar c$ is about 14.

The mass of the electron is given by $m_\varepsilon = \varepsilon^2/2r_0c^2$. The fundamental length r_0 appearing in this formula is also equal to the Compton wave-length of the pion.

Let us assume that the mass of the nucleon is given by a formula strictly similar to that for the electronic mass, in particular with the same value of r_0. Then :

$$\frac{m_n}{m_\varepsilon} = \frac{g^2/2r_0c^2}{\varepsilon^2/2r_0c^2} = \frac{g^2}{\varepsilon^2} = \frac{g^2/\hbar c}{\varepsilon^2/\hbar c} = \frac{14}{1/137} = 1920$$

which is not too far from the experimental value 1840.

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Analysis of Permanent Gases by Gas Chromatography Using a Radioactive Ionization Type Detector

Because of its high sensitivity, simplicity of operation and stability under changing operating conditions, the radioactive ionization-type detector for gas chromatography is one of the most useful so far developed. This detector is, however, relatively insensitive to the permanent gases. From preliminary experiments it has been found possible to increase this sensitivity greatly by introducing a small continuous bleed of organic vapour into the argon carrier stream.

Without the organic vapour bleed into the detector, the mechanism of detection is as described by Lovelock[1]: the argon forms metastable atoms capable of ionizing atoms of any eluted component having a lower ionization potential than argon, and resulting in very high sensitivity to them. The permanent gases, however, have ionization potentials greater than that of metastable argon and hence are not ionized by the argon; thus sensitivity to them is low. Used in this way, the detector current is quite small when the carrier only is passing.

With an organic vapour bleed into the system, the organic vapour is ionized by the metastable argon and produces a relatively high standing ionization current; this is, however, kept below the saturation current of the detector. Permanent gas components entering the detector reduce this higher ionization current to a greater extent than the alteration in current they produce with argon alone. The mechanism of this process may be expected to be complex but can be qualitatively explained from a consideration of energy levels and collision processes.

Using a Pye argon chromatograph with argon carrier gas and a Linde 5A molecular sieve column, it has been found possible to detect permanent gases in the range 0–50 p.p.m. by bleeding ethylene into the carrier stream between the column and detector. With a concentration of ethylene in the detector of the order of 1 p.p.m., the minimum detectable concentrations of hydrogen, oxygen and methane were 0·5 p.p.m. and for nitrogen 1·0 p.p.m. (Similar results were obtained using an acetylene bleed into the detector.) Sensitivity is further increased by a factor of about seven when the ethylene concentration is at its optimum value which would appear to be about 100 p.p.m. In cases where the organic vapour has no adverse effect on the column, it was found possible to include it in the carrier gas supply in the required concentration.

A patent application on this work has been made.

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Etching of Calcite

Experiments on etching of calcite have been carried out earlier by a number of workers[1] and etch pits on calcite have been reported recently by H. Watts[2] and R. C. Stanley[3]. We have been carrying out experiments on etching of mineral crystals with different etching reagents for some time and have investigated calcite very thoroughly. Some typical results are reported here.

On etching cleavage faces of calcite with a strong solution of sodium hydroxide for one hour, perfectly boat-shaped figures are obtained. A light profile photomicrograph is shown in Fig. 1. The depth of this particular etch pit is 1 μ at the centre and 0·8 μ at the ends.

The etch figures produced by ammonium chloride solution on a freshly cleaved surface of calcite are parallelograms, and these are oriented with their sides parallel to the edges; their depths vary from a few hundred angstroms to 2 microns, according to the etching time. Figs. 2 and 3 show photomicrographs for the two stages of etching for fifteen minutes and one hour respectively. In Fig. 2 the pits are more scattered and cleavage lines are found to be moving as reported earlier by Patel and

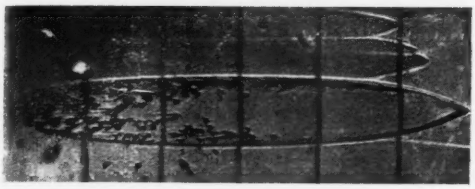
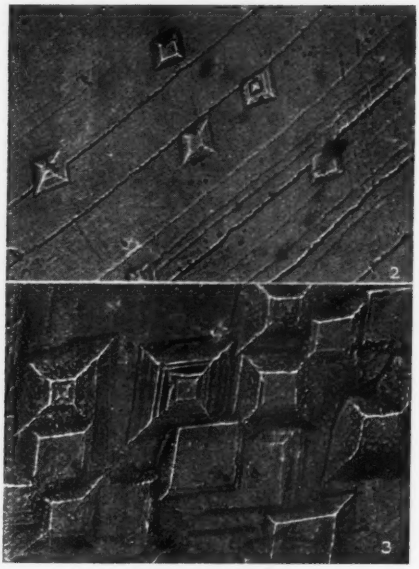


Fig. 1 (×500).



Figs. 2 and 3 (×55).

Tolansky[4] in the case of the etching of mica. Multiple-beam interference pictures have also been taken over these etch pits for measuring their depths.

Detailed results will be published eslewhere.

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Field Effects on Chemisorbed Films in Electron Emission Microscopy

The migration of surface atoms of tungsten under the influence of a high electric field is a well-established phenomenon[1-3]. In addition the migration of multi-layers of adsorbed inert gases in the applied field necessary for field emission has been observed[4]. Strangely enough, the effect of the field on the gases commonly used as adsorbates, namely oxygen, nitrogen, hydrogen, carbon monoxide, etc., does not seem to have been investigated, although field-desorption[5] and the migration of barium[2] have been studied.

We have found that when oxygen is adsorbed by a tungsten emitter at pressures of about 3×10^{-8} mm. in the presence of the applied field, adsorption first occurs around the 011 and 112 planes and particularly on the stepped region joining them, and that only after these appear to be saturated does substantial darkening of the 001 region occur. (A preliminary statement of the effect of the field on carbon monoxide was made at the Fourth International Congress on Electron Microscopy at Berlin in September, 1958, but at that time it was believed that field effects did not occur with oxygen.) This darkening occurs after about 5 min. at the pressure stated. In contrast, if the cleaned emitter is exposed to oxygen at the same pressure for more than 30 min., in the absence of the field, the characteristic black regions around the 001 planes do not form. On applying the field, the 001 regions commence to darken immediately and the process is complete within 3 min.

A similar phenomenon occurs with carbon monoxide, although with this gas the initial adsorption is less specific, a rather granular pattern being obtained without the specific adsorption on the 011–112 'bridge' which is so characteristic of oxygen. Dark circles which engulf the 001 planes are apparent after 12 min. (Fig. 1). If adsorption is allowed to occur for as long as 39 min., at the same pressure, without the applied field, the pattern shown in Fig. 2 is obtained. (Incidentally, this is a convincing illustration of the absence of oxygen contamination.) When the field is now applied, rapid darkening of the 001 region occurs (Fig. 3). The process is apparently irreversible, for 15 min. with the field reversed, fails to have any effect (Fig. 4) on the 001 region.

There appear to be two main reasons why the observed changes could occur at a faster rate in the presence of the field. These are: (i) The production of positive ions in the gas phase which bombard the emitter and so increase the rate of arrival of adsorbate above the value predicted by kinetic theory; (ii) The

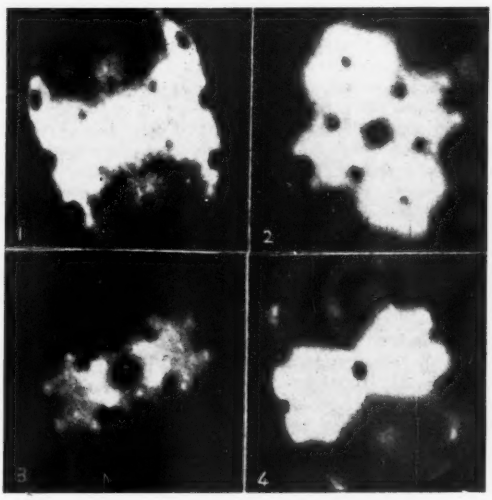

Fig. 1. Emission pattern obtained after adsorption of carbon monoxide for 12 min., at a pressure of 3×10^{-8} mm., in the presence of the field (12·1 kV.).

Fig. 2. Emission pattern obtained after 39 min. exposure in the absence of the field (11·6 kV.).

Fig. 3. Pattern of Fig. 2 3 min. after applying the field (11·4 kV.).

Fig. 4. Pattern of Fig. 3 after 20 min. further exposure in the presence of the field and 15 min. with the field reversed (12·2 kV.). Reversal of the field produced no detectable changes.

roughness of the emitter surface leads to the field being inhomogeneous; polarized adatoms or admoles will thus tend to move to positions where their free energy is a minimum, that is, to where the field is highest. If in the course of such diffusion, the migrating adsorbate meets hole sites such as occur in the 023 planes of tungsten for example, it will tend to be trapped there. We believe that the effects observed with oxygen and carbon monoxide can be accounted for in this manner, rather than by bombardment with ions which would be expected to penetrate well below the surface layers because of their high energies. A fuller account of this and related work will be published in due course.

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METALLURGY

Fatigue-Induced After-Effect in Zinc Single Crystals

Boltzmann proposed his theory of superposition in 1874 to account for the memory effects in deformed materials[1]. Since then the after-effect, namely the tendency of plastically strained materials to return to their original dimensions when the external stress is removed, has received only occasional attention, possibly due to the fact that, in itself, it is not of direct technological importance. When observed in conjunction with forward creep the effect has been called creep-recovery and most of the published work deals with this expression of the phenomenon.

The laws governing the after-effect have been investigated using polycrystalline metal specimens and various attempts have been made to reproduce the phenomenon in single crystals without success[2–5]. This has formed the basis for the theories put forward to explain the after-effect. We have observed large recoverable strains in zinc single crystals originally deformed by creep; a fatigue stress was found necessary to promote the process.

Zinc single crystals, 99·995 per cent purity, were grown from the melt in evacuated capsules in a gradient furnace. The crystals, 7 cm. long and 5 mm. in diameter were annealed at room temperature for several weeks and etched in 20 per cent hydrochloric acid to remove any surface oxide. The straining grips were soldered to the ends of the crystals so as to produce the minimum of end deformation during straining. The orientation χ of the crystals used, which varied between 20° and 22°, was determined by the X-ray back-reflexion Laue method. (χ is the angle between the crystal axis and the glide plane.) The experiments were carried out at room temperature.

A static resolved shear stress of 24·8 kgm./sq. cm. was applied to the crystal resulting in a steady-state creep strain rate of $1{\cdot}4 \times 10^{-4}$/min. After the deformation had passed well into this region the stress was reduced to 4·9 kgm./sq. cm. and the fatigue stress was then introduced. This produced an immediate negative strain-rate which gradually decreased to a vanishing small value. However, by increasing the fatigue stress amplitude further recovery was produced and the effect could be repeated many times as shown in the typical example in Fig. 1.

It was observed that the total recoverable strain increased linearly with fatigue stress amplitude and that the transient part of the recovery curve followed a (time)$^{1/3}$ law, as shown in Figs. 2 and 3 respectively. The magnitude of the effect was found to be dependent on the frequency of the fatigue stress, decreasing with increasing frequency. The frequency-range investigated in the present work was between 10 and 10,000 cycles per sec.

The present observations show that previous theories for the after-effect based on grain boundary behaviour or the uneven distribution of strain in a polycrystalline aggregate are not sufficient in accounting for all cases. The processes leading to the after-effect must have their origin inside the individual grain as well. The dislocation model proposed below appears to explain satisfactorily the observations made in the present work.

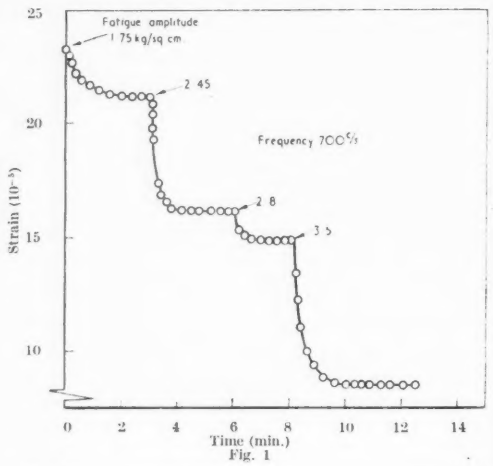

Fig. 1

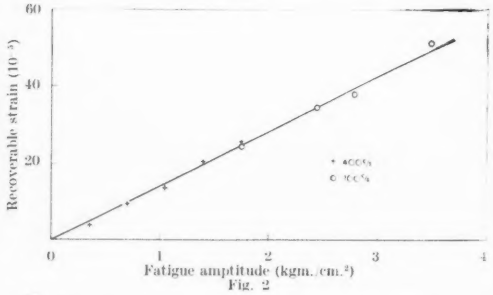

Fig. 2

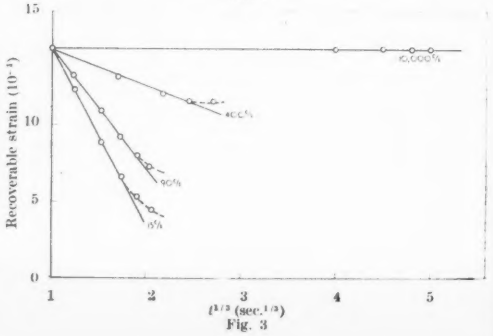

Fig. 3

A proportion of the dislocations generated under the original static stress pile up beneath the free surface of the crystal or against obstacles in the slip plane. When the stress is substantially reduced these dislocations tend to move back towards the generating source under their mutual repulsive stresses. This process is resisted by minor 'frictional' obstacles in the glide plane but the application of a fatigue stress, which causes the dislocations to oscillate, assists them to overcome these obstacles thus increasing their mobility. Larger fatigue stresses would result in more dislocation mobility leading to further strain recovery. It is not clear, however, why a dislocation oscillating at the frequencies used in the present work which are much lower than the 'resonance' frequency of a dislocation line, should become much more mobile than a static dislocation. It is possible that the low-frequency oscillations of the large dislocation networks in the crystal may induce high-frequency oscillations in the smaller elements. Alternatively, the additional energy imparted to the dislocation line, even at low frequencies, may be sufficient to assist it in overcoming the minor frictional obstacles in the slip plane. Experiments are being carried out to reveal which of the two mechanisms is in fact responsible for the effects observed.

Recent evidence in support of the concept of the increased mobility of an oscillating dislocation is given by Meleka and Evershed[6] where a fatigue stress was found to increase forward creep and by Blaha and Langencker[7] who observed a decrease in the static stress required for continued glide when a fatigue stress was applied.

A full account of this work will be published elsewhere.

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Impact Ductile Molybdenum

It has recently been reported that unnotched single crystals of zone-melted molybdenum are ductile in impact well below room temperature[1]. Although the impurity content of this material was very low it was felt that the improvement may be due to the single crystal structure and not the purity. Some crystals were therefore forged and recrystallized to give a polycrystalline material of grain size 4/cm. The specimens were turned to $\frac{1}{4}$ in. diameter and electropolished to produce a surface similar to that of the zone-melted crystals. Tested in a 10 ft./lb. Charpy impact machine these gave a 5 ft./lb. transition temperature of —80°C. compared with —140°C. for similar purity single crystals. A graph of the two sets of results is shown in Fig. 1, the points and full line refer to polycrystals and the broken line to single crystals.

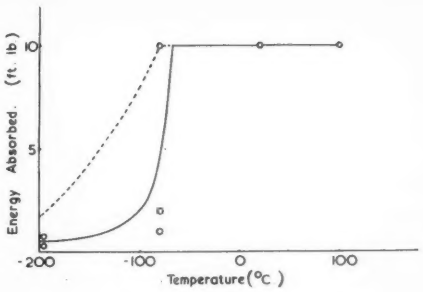

Fig. 1.

The increase in transition temperature may be due to the effect of the grain boundaries or a slightly worked surface layer. No grain boundary facets are apparent in the fracture surface. The transition temperature of recrystallized vacuum-arc-melted molybdenum is about 350°C. under similar conditions. A comparison of the impurity contents in weight per cent of the arc-cast and zone-melted material is given below.

Impurity	Arc-cast	Zone-melted
Carbon	0·01	0·002
Silicon	0·002	0·002
Iron	0·004	0·0001
Copper	0·004	0·001
Chromium	0·001	0·001
Nickel	0·007	0·0001
Cobalt	0·010	0·0002

The oxygen content of both materials is about at the limit of detection of the available vacuum fusion apparatus, approximately 1 part per million.

The surface condition of the recrystallized zone-melted metal was important. Electropolishing improved the impact ductility. Further experiments are in hand to assess to what extent carbon is the impurity responsible for the poor impact properties of arc-cast molybdenum.

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ENGINEERING

Strength of a Grooved Stud

It is commonly accepted that an abrupt change of section (such as a circumferential groove in a bar under the action of tension) will lead to a stress concentration at the root of the groove, and hence to a weakening of the bar in excess of that resulting from reduction in sectional area. That the bar is not necessarily weaker, but may be very much stronger, is now well established but is not generally recognized.

I recently needed to design safety studs which would fracture at a load of 29,300 lb. with a maximum coefficient of variation of 1·3 per cent. The studs were 7 in. long and $1\frac{1}{2}$ in. in diameter with a circumferential groove of semi-circular section turned on it with a parting tool. It was found that the studs broke at loads which were 60 per cent greater than those calculated from the tensile strength (28/33 tons/sq. in.) of the material (which was structural steel), and the cross-sectional area. The test results are shown in Table 1.

Table 1. Results of Groove Test

Diam. at Groove d (in.)	Ratio D/d	Limit of Proportionality 1,000 lb.	Limit of Proportionality tons/sq. in.	Yield Point 1,000 lb.	Yield Point tons/sq. in.	Tensile Strength 1,000 lb.	Tensile Strength tons/sq. in.	Remarks
0·778	1·93	n.o.	n.o.	n.o.	n.o.	51·2	48·1	Trial stud (scrap material)
0·591	2·54	n.o.	n.o.	n.o.	n.o.	30·8	50·1	Bar 1
0·5763	2·60	n.o.	n.o.	n.o.	n.o.	29·0	49·7	Bar 1
0·5800	2·59	n.o.	n.o.	n.o.	n.o.	29·2	49·3	Bar 1
0·5805	2·58	n.o.	n.o.	n.o.	n.o.	29·4	49·6	Bar 1
0·577	2·60	11·4	24·6	17·8	30·3	28·9	49·2	Bar 1
0·531	2·82	n.o.	n.o.	15·2	30·6	24·2	48·6	Bar 1
0·520	2·88	n.o.	n.o.	14·8	31·1	23·2	48·8	Bar 1
0·518	2·90	n.o.	n.o.	14·4	30·4	23·0	48·6	Bar 1
—	1·00	n.o.	n.o.	8·4	18·1	142·5	30·7	Bar 1 Full section test results
1·005	1·49	29·0	16·4	48·3	27·3	76·4	43·0	Bar 2
1·202	1·25	44·0	17·3	55·5	21·8	100·5	39·7	Bar 2
0·421	3·56	4·1	13·2	7·3	23·4	13·4	43·0	Bar 2
0·581	2·58	8·3	14·0	15·0	25·3	26·0	43·6	Bar 2
—	1·00	—	9·0	—	15·2	—	27·1	Bar 2. Assumed figures.

D (full diameter of stud), 1·5 in.
n.o., no attempt made to observe this property.
Bar 2, no test data available on full section : quoted figures obtained by comparison of studs of 0·58 in. diameter.

From the point of view of stress-concentration, the stress condition, according to Petersen[1], is one of bi-axial tension, that is, axial tension together with circumferential tension. Yielding should then depend upon the axial stress value only, since the lowest principal stress remains zero. Assuming an elastic condition, Petersen calculated that the axial stress was 1·7 times that in a plain bar of the same diameter. Allowing for the fact that yielding depends on the Mises criterion, the stress concentration was calculated to be 1·6 at the yield point.

Orowan[2] has pointed out that the stress system at the root of a groove of this type very rapidly becomes tri-axial tension because of the constraining effect of the groove in preventing the development of yielding. This fundamentally alters the picture, because the two smaller principal stresses become equal to each other and rise with the axial stress. Under this condition, yielding cannot proceed any further, and the material will stand very high stresses until it breaks in a brittle fashion at the value of maximum principal (axial) stress which is the limit for the material. Orowan postulates that this limit is such that the studs could not have their apparent tensile strengths increased by more than 3·3 times by an infinitely sharp groove.

With this background most of the experimental results could be explained. The 'plastic constraint factor' (to use Orowan's term) was about 1·6; but his theory did not explain the observed increase in yield point and limit of proportionality. These were measured by Martens-type extensometers indicating axial extension across the grooves. In each case the increase was almost as great as the 'plastic constraint factor'. It seems that a very small plastic flow was sufficient to produce the tri-axial condition, and that the shear stress did increase somewhat so that yielding still occurred generally across the sections.

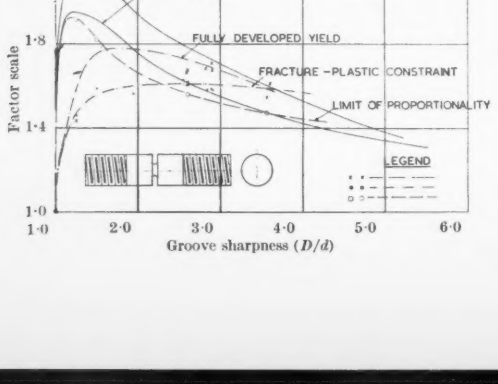

Fig. 1 shows the various factors plotted against a groove sharpness parameter D/d, with further factors comprising the ratios of yield strength and limit of proportionality. It is interesting to note the close resemblance of the Petersen (Mises criterion) stress-concentration curve with the experimental curve for limit of proportionality. The discrepancy between the shape of both the Petersen curves and the experimental curve for fracture is very great.

The fractured specimens showed mainly brittle failure except for narrow bands of ductile failure around the edge.

In view of the evidence of reasonable ductility, and the fact that the desired coefficient of variation was easily obtained, manufacture of the safety studs was continued and they have, in fact, given perfectly satisfactory service.

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CHEMISTRY

Dielectric Absorption in Dispersed Systems

If a high-frequency alternating field is applied to a system containing mobile ions or movable dipoles, the loss factor should increase when the applied frequency approaches the natural relaxation frequency of the system. In dilute aqueous solutions of simple electrolytes this frequency is of the order 100 Mc./s. (Falkenhagen effect); in pure water it is 10,000 Mc./s. (dipole oscillation effect). With polyelectrolytes the cylindrical symmetry of the ionic atmosphere results in a much slower relaxation (0·1–1 μ sec.)[1], and we have now found a similar effect but with a much higher loss factor for microscopic two-phase systems, such as fibres, suspensions and emulsions, with water as the continuous phase. It also occurs in disperse systems where the continuous phase is an insulator, and is indeed more easily verified than with aqueous systems, when the frequency-independent conductance may mask the critical frequency effect.

We prefer to use bridge methods, on account of their high accuracy but it is very easy to be misled by spurious effects due to electrical 'strays' and

'residuals' in the megacycle frequency-range. Even short leads are inadvisable above 5 Mc./s.; we use a micrometer cell sitting directly on the terminals of a product arm radio-frequency bridge, which accepts its initial balance at zero resistance, with the cell electrodes in contact.

Work is proceeding with polyelectrolytes, where no dependence of critical frequency on degree of polymerization has yet been found. With emulsions and suspensions, on the other hand, particular size does have a specific effect, which is being examined.

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'Thermal Regeneration' in the Nickel-Oxygen System

Observations of photo-electric 'activation' (lowering of the photo-electric threshold energy) through the interaction of small quantities of oxygen with various metals are recorded in the literature[1]. Such activation, for which no satisfactory theory has been advanced, is obtained without heat treatment and most of the metals concerned possess a low work function (below about 3 eV.). Large admissions of oxygen always cause the reverse effect: the threshold is shifted to shorter wave-lengths. The phenomenon of 'thermal regeneration', that is the removal of oxygen from the surface of certain metals and semiconductors by heating *in vacuo*, is also well established. The oxygen which disappears from the surface in these cases is not desorbed; it is either incorporated by regions below the surface[2,3] or it is effectively aggregated into islands on the surface as the result of recrystallization processes to leave bare areas[4]. We have observed photo-electric activation in nickel films (work function about 5·1 eV.) after interaction with oxygen followed by thermal regeneration of the surface. There appears, therefore, to be a close parallel between thermal regeneration and photo-electric activation. Further, we have found that regeneration of a nickel surface to which oxygen has been admitted at 20° C. occurs spontaneously on standing *in vacuo* at that temperature.

Table 1. Work Functions of Evaporated Nickel Films Undergoing Interaction with Oxygen

Surface	Work function (eV.)
Freshly evaporated Film I	5·15
Throughout stepwise chemisorption of O_2 at 20° C.	5·04
Stood in 10^{-4} mm. O_2	5·24
Pumped and raised to 400° C. in 1 hr. Cooled rapidly	4·87
Resaturated with O_2	5·23
Freshly evaporated Film II	5·14
Stood 14 hr. in 3 mm. O_2. Pumped and raised to 400° C. in 1 hr. Cooled rapidly	4·66
Excess O_2	5·19
Pumped. Stood 2 days *in vacuo*	5·09
Raised to 400° C. in 1 hr. Cooled rapidly	4·78
Resaturated with O_2	5·33
Film III, after oxidation followed by complete reduction with H_2 and outgassing at 500° C.	5·09
At once after admission of O_2 at 20° C. Surface just saturated	5·39
After 15 hr. *in vacuo* at 20° C.	5·28
After 42 hr.	5·18
After 66 hr.	5·16
After 135 hr. (An adsorptive capacity was restored in this surface.)	5·15

Photo-electric measurements were made at 20° C. in an all-glass photocell using evaporated nickel films as the photocathode. Photo-electric charges were recorded in a Compton quadrant electrometer using the method of charge-up in an isolated circuit. Spectral sensitivity data were plotted as the square root of the photo-electric yield versus wave-numbers[5]. For all except clean films (which possessed unique work functions) the points corresponding to any one run could be fitted to two straight lines: double thresholds were inferred accordingly. The work functions presented in Table 1 correspond to the lower thresholds only.

These results indicate that, in the case of the nickel-oxygen system, regeneration occurs slowly at 20° C., but only to a limited extent (the work function does not fall much below that of the clean metal surface). Thermal regneration, however, causes a marked fall in the work function, which may be as much as half a volt lower than that of the metal. It therefore appears unlikely that bare metal surface is responsible for the observations accompanying thermal regeneration. We tentatively suggest that both regeneration and photo-electric activation are the manifestations of a cation-rich surface (positive surface potential) such as may result from a migration of cations through the thin oxide film. It is possible that these phenomena are general to all oxygenated surfaces. Thus the extent to which regeneration is observed appears to depend only on the surface concentration of oxygen and the extent of the electronic interaction with the metal or semiconductor involved.

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Polymerization of Phosphonitrilic Chlorides

It has been stated[1] that phosphonitrilic chlorides polymerize by a free-radical mechanism. If this were so the reaction could be initiated by high-energy radiation.

Since the phosphonitrilic chlorides are solids at room temperature (the melting point of $(PNCl_2)_3$ is 114°C.) this would provide a convenient method of polymerization[2].

Six specimens of a commercial mixture of phosphonitrilic chlorides [Albright and Wilson Ltd.], enclosed in evacuated glass tubes, were exposed in the Spent Fuel Irradiation Facility of the Atomic Energy Research Establishment to $0{\cdot}6 \times 10^6$ rads/hr. of gamma radiation. The total radiation received varied from 10^6 to 10^8 rads. Using the same rate of gamma radiation Chapiro[3] and his colleagues obtained 0·5 per cent conversion per hour for styrene with higher conversions in the cases of non-aromatic compounds.

Two of the irradiated samples were heated at 90°C. for 2 hr. without significant change in the percentage of material which was soluble in benzene. When phosphonitrilic chloride is polymerized by heating to 250°C. a long chain rubber is formed ; no sign of this was seen in any of the irradiated specimens.

The specimens were extracted with benzene, in which the polymerized phosphonitrilic chloride is insoluble ; in no case was the amount of insoluble matter significantly different from that of the starting material. This was approximately 3 per cent which presumably represents low molecular weight linear polymers in the commercial mixture.

Further specimens which were irradiated by means of a linear accelerator up to 10^9 rads, also showed no signs of polymerization. As this is three orders of magnitude greater than the dose[3] required to initiate the polymerization of styrene it would appear that free radicals do not initiate the polymerization of phosphorus nitrilic chlorides.

For all these irradiations I am indebted to Dr. R. Roberts and the Technological Irradiation Group of the Atomic Energy Research Establishment, Harwell.

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A Method for Determining Carbon-14 by Combustion using Calcium Carbonate

When organic material is to be analysed quantitatively for the content of carbon-14 by combustion a standard method is to convert all the carbon into carbon dioxide which is then absorbed in a solution of sodium hydroxide[1]. The carbonate thus formed is then precipitated by the addition of barium chloride and the total amount of carbon present determined by back titration with hydrochloric acid. The barium carbonate is collected in a manner suitable for counting

Precipitation by barium chloride is convenient because accurate back titration is possible, and the precipitate can be collected fairly easily on a filter paper to give an even deposit suitable for counting. Where the total amount of carbon in the sample is small, the high atomic weight of barium is advantageous in bulking up the precipitate, but it also carries the disadvantage that there is high self absorption and consequently in comparison with lighter elements the sensitivity of counting is reduced.

Thus when there is adequate carbon available (in excess of 10 mgm. for a 2·4 cm. diameter end counting window) a carbonate formed from a lighter metal can give valuable extra sensitivity which may be especially needed when the material being assayed is of low activity.

Of the commoner metals with a low atomic weight only calcium carbonate gives a highly insoluble carbonate necessary for quantitative analysis. It has been found (Table 1) that when a comparison is made between precipitates to 'infinite thickness' of barium carbonate and calcium carbonate prepared from material of the same specific activity calcium carbonate gives an increased counting rate over barium carbonate by a factor of $1{\cdot}85 \pm 0{\cdot}08$ (cf. the molecular weight ratio of barium carbonate to calcium carbonate of 1·98:1).

Unfortunately precipitates of calcium carbonate formed by adding calcium chloride to mixtures of sodium hydroxide and sodium carbonate show a tendency to be gelatinous, and titration is made difficult and irreproducible by fading end-points. The calcium carbonate crystals which form on standing may also be large and thus tend to form uneven preparations because filtration is too rapid.

It has been established that these difficulties can be avoided by adding magnesium chloride to the calcium chloride—a convenient proportion is one part magnesium chloride to two parts calcium chloride. With this mixture, back titration is consistent and reliable when thymol blue is employed as the indicator. The end-point is not so readily recognized when the mixture of the calcium and magnesium chloride is substituted for barium chloride ; but a warning of the approach of the end-point is given by a change in colour from blue to grey. Titration should not be carried out until sufficient time has elapsed for precipitation to be completed. About 1 hr. has been found to be satisfactory for a wide range of conditions. The precipitates formed are not gelatinous, and the crystals are fine enough to give good filter preparations which can be dried without the cracking and distortions which may be produced by precipitates of barium carbonate. Moreover, the addition of magnesium chloride gives precipitates which show less tendency to stick to the flask.

These findings are based on a series of tests over a range of total alkalinities and ratios of sodium hydroxide to sodium carbonate (Table 1). Precipitating agents were all added in excess. All precipitates were prepared by filtration on to filter paper disks to 'infinite thickness' (more than 100 mgm.) and replicated samples counted to 10,000 counts. From Table 1 it can be seen that calcium carbonate precipitates from calcium chloride alone as against the magnesium chloride mixture on average exhibit a slightly greater activity which is statistically significant ($P = 0{\cdot}01$). It is probable therefore that the precipitates from the mixed chlorides are slightly contaminated with magnesium hydroxide (not magnesium carbonate as this would tend to increase the sensitivity). Qualitative analysis shows magnesium to be present in the precipitates. The reason why magnesium chloride is effective is not understood.

Table 1.

Alkali concentration (Normality)	Ratio NaOH : Na_2CO_3	Titration Accuracy % of Theoretical Equivalent: $BaCl_2$	$CaCl_2$	$CaCl_2 + MgCl_2$	Counting Sensitivity Ratio: $BaCl_2$	$CaCl_2$	$CaCl_2 + MgCl_2$
High N = 0·4	1 : 1	97	85	95	1	1·83	1·77
	1 : 3	98	90	96	1	—	1·77
Medium N = 0·2	3 : 1	100	92	100	—	—	—
	1 : 1	101	103	100	1	1·96	1·83
	1 : 3	100	106	101	1	—	1·78
Low N = 0·1	3 : 1	100	99	100	1	1·87	1·88
	1 : 1	100	109	101	1	1·87	1·79
	1 : 3	100	107	102	1	1·96	1·93

Normal hydrochloric acid was used for titration throughout.

I am indebted to Prof. G. E. Blackman and members of his staff for their guidance and encouragement.

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Aromatic Ring Opening in the Presence of Oxygen in Irradiated Solutions

When aqueous solutions of benzene are irradiated *in vacuo* with α-rays or neutrons which produce oxygen, a dialdehyde, identified as mucondialdehyde, is produced[1]. The same product was found also when solutions of benzene containing oxygen were irradiated with X-rays[2]. Thus ring opening appeared to be connected with the presence of oxygen, rather than with high radical concentrations and multiple reactions on the same benzene ring. The identification of the product as mucondialdehyde was confirmed[3]. Material balance cannot be obtained[4] unless the formation of oxidation products other than phenol is assumed. The interesting possibility arises that aromatic ring opening in the presence of oxygen may occur as the result of a single primary radical reaction step and that mucondialdehyde is a primary product, being formed in direct competition with the formation of phenol. Analytical methods were used which enabled us to determine phenol, catechol and quinol[1,2] in the presence of hydrogen peroxide[5] and of mucondialdehyde, *o*- and *p*-quinone. These last three were determined after condensation with *p*-NO_2-phenylhydrazine in 2 *N* sulphuric acid, extraction into carbon tetrachloride, re-extraction into 2 *N* sodium hydroxide and spectrophotometric measurement in 0·8 *N* sodium hydrate at 390 mμ (mucondialdehyde); 510 mμ (max.) and 400 mμ (min.) (*o*-quinone); and 475 mμ (*p*-quinone). Details of the analytical methods developed will be published separately.

We have found that mucondialdehyde is indeed formed simultaneously with phenol, directly from benzene, without the previous formation of phenol, catechol, quinol or quinones. In Fig. 1 it is shown that in aqueous benzene solution irradiated with X-rays at $pH = 7{\cdot}1$, while phenol is formed with an initial yield of $G = 2{\cdot}69$, mucondialdehyde is being formed with an initial yield of $G = 0{\cdot}8$. Under the same conditions quinones are not formed in measurable quantities. The addition of phenol to the solution before irradiation does not increase the yield of mucondialdehyde. The ratio of G (phenol)/G (mucondialdehyde) remains constant at ~ 3 in the range $pH = 0{\cdot}4 - 7{\cdot}5$. The absolute yield increases slightly at low *p*H values.

One possible explanation of the direct aromatic ring opening is that due to Weiss[6], who assumes that the addition to benzene of one radical formed from water by the radiation leads to further addition of oxygen and formation of a hydroperoxide which, losing water, yields mucondialdehyde directly through ring opening. Alternative possibilities include the interaction of an excited benzene molecule with oxygen leading to direct ring opening and dialdehyde formation.

We have therefore investigated the photochemistry of aqueous benzene solutions containing oxygen, irradiated with ultra-violet light of wave-length above 2100 A. Formation of phenol and mucondialdehyde was observed, mucondialdehyde being once again a primary product formed in competition with the formation of phenol. The ratio of phenol/mucondialdehyde however changes with changing *p*H, the relative yield of mucondialdehyde decreasing strongly with decreasing *p*H. The different degrees of dependence on *p*H would indicate that the mechanisms involved in photochemistry and radiation chemistry are not wholly identical.

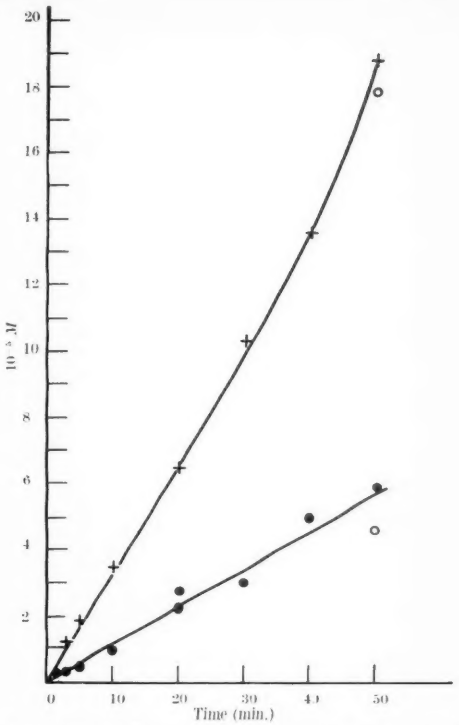

Fig. 1. Formation of phenol (+) and mucondialdehyde (●) in oxygenated benzene solution at $pH = 7{\cdot}1$, o, results in presence of initially added pheno (2×10^{-4} *M*). 200-kVp. X-rays, 1380 r./min.

It appears therefore that the interaction with molecular oxygen of both an excited benzene molecule or of a radical formed from benzene may lead in aqueous solution directly to aromatic ring opening. We are investigating the possible connexion with the known effect of oxygen on the spectrum of benzene[7].

Full details will be published separately.

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BIOCHEMISTRY

Isolation of 2-Aminoethane Phosphonic Acid from Rumen Protozoa

In the course of experiments on the amino-acid composition of rumen Protozoa, an unknown ninhydrin-positive substance was found by paper chromatography to be present in acid hydrolysates of the ether-ethanol soluble fraction of Protozoa. The substance was isolated in crystalline form and identified as 2-amino-ethane phosphonic acid,

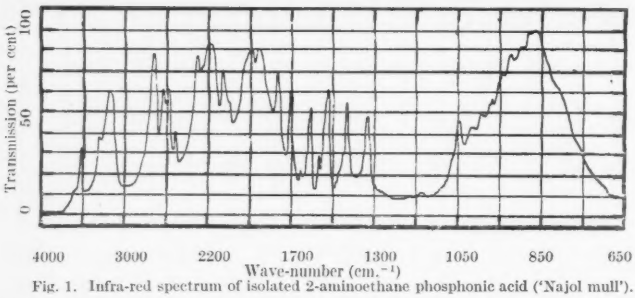

Fig. 1. Infra-red spectrum of isolated 2-aminoethane phosphonic acid ('Najol mull').

$H_2N{\cdot}CH_2{\cdot}CH_2{\cdot}PO(OH)_2$, (synthesized by Finkelstein[1], Kosolapoff[2], Hackspill[3] and Chavane[4]).

The isolation of this new amino-phosphonic acid was made possible by using paper chromatography for following the compound through each stage in the process.

Protozoa were obtained by a modification of the method of McNaught *et al*[5]. Rumen contents were taken out through the rumen fistulas of two sheep maintained on daily rations consisting of 250 gm. of concentrate mixture (equal parts of soybean cake and wheat bran) and 4 kgm. of green grass or 1 kgm. of dried grass. The contents were diluted with equal volumes of 0·5 per cent glucose and 0·5 per cent sodium chloride solution (39°C.), and squeezed through 8-folded surgical gauze. The liquid was then poured into cylinders and allowed to stand in a warm water-bath (39°C.). After a short time, the floating fibrous layer was removed by suction and the liquid was decanted, and the well-defined layer of larger Protozoa at the bottom was collected. The fibrous layer was well mixed with glucose - sodium chloride solution and allowed to settle once more to remove any Protozoa trapped in the fibrous materials. The liquid obtained by decantation was centrifuged (approximately 3,000 r.p.m.) and the smaller Protozoa were collected. The combined protozoal fractions were resuspended in glucose - sodium chloride solution and then treated in a manual centrifuge repeatedly until the supernatant layer was quite clear. The latter treatment is essential to obtain the Protozoa almost free from bacteria. Microscopic examination of the protozoal preparation showed that it contained no extracellular material, and its fibre content measured by the method of A.O.A.C. (1950) was 0·0 per cent. The Protozoa, which were still actively moving, were then preserved in acetone, filtered and air dried. In all, 50 kgm. of rumen contents were treated in this way giving a total yield of 203 gm. of Protozoa on a dry basis.

The fauna consisted of *Diplodinium* (mainly *D. magii* and *D. ecaudatum*), *Isotricha*, *Ophryoscolex*, *Dasytricha* and *Entodinium* (mainly *E. simplex*, *E. longinucleatum* and *E. caudatum*). *Entodinium*, *Ophryoscolex* and *Dasytricha* constituted a large portion of the whole.

The Protozoa were extracted with several portions of hot ether - ethanol (1:1). The extract was hydrolysed by refluxing for 13 hr. with 100 ml. constant-boiling hydrochloric acid. After extracting the resultant lipids with ether, the hydrolysate was taken to dryness and transferred with 4 ml. of water to a bed (1·3 cm. × 4 cm.) of 'Dowex 50-*X*4' (hydrogen form). After washing the bed with water, the fraction containing acidic and neutral amino-acids was eluted with 5 per cent pyridine. The eluate was taken to dryness and transferred to a column (1·1 cm. × 58 cm.) with 2 ml. of 0·6 *N* hydrochloric acid. Elution was carried out with 0·6 *N* hydrochloric acid. Under these conditions, the compound emerged from the column after about 150 ml. as a single peak. The pooled effluent fractions containing the compound were concentrated to dryness, and the resultant liquid was transferred with 1–2 ml. of 0·5 *N* acetic acid to a bed (1·1 cm. × 4 cm.) of 'Dowex 1-*X*8' (acetate form). The bed was washed with 0·5 *N* acetic acid until aliquots from successive portions of the effluent were negative to ninhydrin. The first 7 ml. of the effluent usually contained all this compound. The effluent was taken to dryness, dissolved in a small amount of 5 per cent acetic acid and treated with a small bed of decolourising carbon. Then the compound was obtained in crystalline form upon evaporation of the acetic acid, and recrystallization from water - ethanol gave 63 mgm. of tiny rhombic crystals.

The compound had a melting point of 295–297° (decomp.); (found: C, 19·57; H, 5·66; N, 11·34; P, 24·7. $C_2H_8NPO_3$ requires C, 19·20; H, 6·55; N, 11·20; P, 24·76 per cent); the nitrogen was present entirely as amino-nitrogen, as shown by the Van Slyke amino-nitrogen method; the compound was soluble in water; less soluble in methanol; insoluble in ethanol, acetone, ether and benzene. It was optically inactive and had no unsaturated bond. Hydrolysis with 5 *N* sodium hydroxide at 120° for 8 hr. did not liberate phosphoric acid. The infra-red spectrum (Fig. 1) showed the absence of COO^- in the molecule. From the titration curve the molecular weight was estimated as 125.

From these results, the compound was assumed to be 2-aminoethane phosphonic acid, and this was synthesized by us by Chavane's method[4]. The isolated and synthetic compounds behaved identically on paper chromatograms developed in *n*-butanol-acetic acid-water, phenol-water, and lutidine-aniline-water solvents, and showed the same infra-red spectra.

Phosphorus is combined with other elements in organisms, as well as in their products, giving O-P, O=P and N-P; now the occurrence of the C-P bond has been demonstrated. It will be interesting to investigate whether this compound is widely distributed in Nature or occurs only in rumen Protozoa.

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Presence in Rose Hips of Substances Inhibiting the Oxidation of Ascorbic Acid

It has been demonstrated that even AnalaR grade chemicals may contain sufficient heavy-metal impurity to catalyse the oxidation of ascorbic acid[1]; it was found that this oxidation was diminished by the addition of an aqueous extract of the flesh from hips of *Rosa canina*. The protective action of the hip extract was then tested in the presence of extracts of cauliflower ascorbic oxidase, apple polyphenolase and horseradish peroxidase. In each case reaction

Table 1. THE EFFECT OF AN AQUEOUS EXTRACT OF HIP FLESH ON THE OXIDATION OF ASCORBIC ACID BY DIFFERENT SYSTEMS

Oxidizing system	Initial rate of oxidation of ascorbic acid (mgm./ml. of reaction mixture/10 min.)		Reduction in rate caused by hip extract (per cent)
	Control	+hip extract	
Cauliflower ascorbic oxidase	0·098	0·060	39
Apple polyphenolase	0·112	0·087	22
Horseradish peroxidase	0·23	0·022	90
$2\times10^{-5}M$ added copper sulphate	0·085	0·003	96

mixtures were prepared containing the oxidase system, hip extract and added ascorbic acid (final concentration, about 1·0 mgm./ml.) buffered to *p*H 6·0; the mixtures were incubated at 25°C., aerated and samples taken at intervals for the assay of residual ascorbic acid. Controls were also run, containing only the oxidase system, buffer and added ascorbic acid. To confirm the effect on metal-catalysed oxidation, a further mixture was made consisting of buffer, ascorbic acid and copper sulphate (final concentration, $2\times10^{-5}M$). Table 1 gives the average results for a number of replicate experiments.

The 'protective' substance or substances were thermostable and insoluble in ether but soluble in ethanol and acetone. An acetone extract was therefore reduced to dryness under vacuum and the residue, in aqueous solution, was streaked on to Whatman No. 3 paper and run in butanol/acetic acid/water (4:1:5). The chromatogram was halved, and one half was further cut into several longitudinal strips; each strip was then sprayed with a different reagent. The other half was cut into ten transverse sections; each section was eluted with water and the eluates assayed for inhibitory activity as before, using cauliflower ascorbic oxidase. Controls were obtained from the eluates of the sections taken from before the starting line and from beyond the solvent front. Two inhibitory fractions appeared; the first fraction giving the larger inhibition (63 per cent) remained on the starting line, had a brown colour, gave a darker brown colour with ammoniacal silver nitrate, a dark coloration with ferric chloride and reduced 2:6 dichlorophenolindophenol very slowly. The second fraction giving the smaller inhibition (30 per cent) was centred at R_F 0·5, and seemed to be associated with a band of yellow and blue fluorescence which appeared in ultra-violet light after spraying with dilute ammonia; it also gave a pale, greenish-blue colour with ferric chloride.

The identities of the two fractions, and the effect of each of them on the other oxidases, have still to be worked out. In their combined effect on the three oxidases they resemble the inhibitor found in certain fruits and vegetables by Somogyi[2]; so far as affinity to the tannins is concerned, there is a similarity to the fraction isolated from the Indian gooseberry by Damodaran and Nair[3]. The function of these inhibitors *in vivo* is not known. It is perhaps significant, however, that: (*a*) the flesh of rose hips possesses to a remarkable degree the ability to accumulate ascorbic acid, and (*b*) the oxidation of ascorbic acid *in vitro* by the main, soluble oxidase of the tissue (a peroxidase) is also inhibited by the 'protective' substances described above.

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Dietary Protein and Serum Cholesterol in Rats

IN order to study the influence of the diet on atherosclerotic changes in experimental animals, diets have been developed which produce a high level of cholesterol in the blood. The degree of hypercholesterolæmia is known to be dependent on several dietary factors, including the amount of protein.

In previous experiments with rats marked differences in the serum cholesterol level were observed if different protein concentrates were added to a hypercholesterolemic diet consisting of 15 per cent casein, 20 per cent hydrogenated coconut oil, 4 per cent minerals, 2·1 per cent vitamin mixture, 0·2 per cent choline chloride, 1 per cent cholesterol, 0·2 per cent cholic acid and 67·5 per cent starch. The addition of 5 per cent wheat gluten resulted in a considerably lower cholesterol level than did the same amount of either gelatin or casein[1]. Low serum cholesterol levels have also been observed in rats fed on diets containing wheat gluten as the only source of protein[2].

In order to obtain more information on the cholesterol-lowering effect of various proteins, groups of 10–12 newly weaned male and female rats were fed the above hypercholesterolæmic basal diet with supplements of different protein concentrates or amino-acids. Additions were made at the expense of an equal amount of wheat starch. Growth and food consumption were recorded during 4 weeks. Thereafter the blood was analysed for total serum cholesterol content by the Liebermann-Burchard reaction. Results are presented in Table 1.

Each of the protein supplements added in a concentration of 5 per cent of the ration caused a decrease of the serum cholesterol level (experiment 1). The lowest levels were obtained with dried whole egg, wheat gluten, fish meal and meat meal. Supplements of casein, gelatin and soybean protein were less active in lowering serum cholesterol. The proteins with the higher activity supported faster weight gain.

In a subsequent experiment (experiment 2) the same low cholesterol level was obtained when a mixture of amino-acids based on the composition of wheat gluten was substituted for the intact protein. Moreover it was observed that the addition of different combinations of each three essential amino-acids (in concentrations of 0·2, 0·4 and 0·6 per cent respectively) lowered the cholesterol level if methionine was one of the three. This effect was paralleled by faster weight gain and increased food consumption.

Table 1. MEAN TOTAL SERUM CHOLESTEROL (MGM./100 ML.).

Experiment	Addition to basal diet	Total serum cholesterol
1	None	1021
	Casein	863
	Gelatin	780
	Soybean protein	763
	Meat meal	642
	Cod-fish meal	579
	Wheat gluten	571
	Dried whole egg	555
2	None	1777
	Wheat gluten	668
	Amino-acids of wheat gluten	660
	Histidine, lysine, isoleucine*	1578
	Methionine, threonine, phenylalanine	843
	Tryptophan, valine, leucine	1603
	Histidine, threonine, leucine	1379
	Tryptophan, lysine, phenylalanine	1739
	Methionine, valine, isoleucine	736
3	None	1058
	Wheat gluten	468
	Butanol extracted wheat gluten	552
	Butanol extract of wheat gluten	759

* Respectively 0·2, 0·4 and 0·6 per cent of the ration.

These results suggest that the cholesterol-lowering effect of protein concentrates may be ascribed primarily to the amino-acids, especially methionine. This view is supported by the well-known hypercholesterolæmic effect of methionine, as observed in experiments with mice[3], rates[3,4] and chicks[5-7]. Moreover the basal diet used in our experiments is deficient in amino-acids containing sulphur, as it contains casein as the only source of protein in a suboptimal amount.

Recently, however, Nath and Harper[8] arrived at the conclusion that the cholesterol-lowering properties of wheat gluten are associated with the lipid fraction which may be removed by prolonged extraction with hot butanol. In our experimental design, however, wheat gluten extracted with butanol, showed nearly equal activity in lowering serum cholesterol as untreated wheat gluten, whereas the corresponding amount of butanol extract was less active (experiment 3).

Further experiments are necessary to evaluate the significance of amino-acids and accompanying lipids of protein-rich foods with respect to their cholesterol-lowering properties.

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Glutamic-Pyruvic Transaminase in Rabbit's Long Bones

The finding that a transamination process is operative in metaphyseal cartilage of growing animals[1] led to drawn some relationship between protein metabolism and mineralization[2]. Moreover, the observation that cortisone treatment which is known to inhibit skeletal development[3] probably through a blocking activity on sulphate incorporation in the mucopolysaccharides[4] of the organic matrix, also decreases the activity of glutamic-oxalacetic transaminase in metaphyseal cartilage[5], suggests an active participation of transamination to osteogenesis, or at least in one of the metabolic processes leading to mineralization.

The relatively high level of pyruvate in pre-osseous cartilage[6] prompted us to check the presence in this tissue of an enzyme involved in the utilization of this substrate, namely, glutamic-pyruvic transaminase. This enzyme can be used as an indicator of amino-acid metabolism[7]. In order to connect the activity of this enzyme with mineral deposition, it was determined in three zones of the long bones of young rabbits in which mineralization (1) had not yet begun, (2) was proceeding, and (3) was already completed, namely, epiphyseal cartilage, the zone of the secondary spongiosa and cortical bone respectively.

The bones, which were obtained from 15-day-old rabbits, were quickly excised and chilled in ice. Glutamic-pyruvic transaminase was determined in the three zones mentioned above after careful homogenization of the tissues in a Waring blendor. The reaction was followed for 30 min. at 37° C., following the method of Caldwell[8].

Table 1. Glutamic-Pyruvic Transaminase in Three Zones of Young Rabbit's Bone. (Average Values of Nine Determinations.)

	Metaphyseal cartilage	Secondary spongiosa	Diaphyseal bone
µmole pyruvate utilized/mgm. bone (dry weight) /30 min.	0·110 ± 0·038	0·299 ± 0·040	0·028 ± 0·008

The results show that besides aspartic–α–keto-glutaric[1] glutamic-pyruvic transaminase, is present in ossifiable cartilage. The comparison of the activities in the three zones shows a close relationship between the amount of the transamination and the degree of mineral deposition. The results obtained here do not show whether this fact is in some way related to an essential step in the bone-forming process, or whether it is only the expression of the local proteolysis which takes place during the osteoclastic resorbtion and reconstruction to which the zone of the secondary spongiosa is subjected[9]. However, the finding that testosterone treatment, which has a favourable influence on bone formation[10], increases transamination in metaphyseal cartilage[5] while corticoids, which are known to inhibit skeletal development[11], decrease transamination activity[5], and the results reported here are consistent with an involvement of glutamic-pyruvic transaminase in osteogenesis.

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Formation of Leucrose in Dextran-Producing Cultures of *Streptococcus bovis*

In addition to dextran and fructose a mixture of reducing disaccharides, containing glucose and fructose, is formed when *Leuconostoc mesenteroides* strains are grown in sucrose media[1]. The same disaccharides are produced when cell-free dextransucrase, obtained from a sucrose culture of *L. mesenteroides*, is incubated with sucrose[2]. From this disaccharide mixture Stodola, Sharpe and Koepsell[2] isolated one of the components as a crystalline compound. The pure sugar, named leucrose, was markedly resistant to acid hydrolysis and was shown to have the structure 5-O-α-D-glucopyranosyl-D-fructose[2]. In recent studies on the production of dextran from sucrose by rumen strains of *Streptococcus bovis*[3,4] it was noted that similar acid-resistant reducing disaccharides were formed in good yield when dextran was being produced. The exact nature of the sugars was not determined at the time. An examination of the disaccharide fraction has now been made.

Culture fluid (200 ml., freed from dextran) obtained from a 48 hr. culture of *S. bovis* (strain 1)[4] was fractionated with aqueous ethanol on a charcoal-celite column. The syrupy disaccharide fraction obtained (0·5 gm.) was crystallized by the method of Stodola, Sharpe and Koepsell[2] to yield, finally, 0·15 gm. of twice-recrystallized sugar. The sugar was shown to

be identical with authentic leucrose by the following evidence.

After acid hydrolysis under conditions giving minimum fructose destruction (5 mgm. in 1 ml. of 0·25 *N* hydrochloric acid for 3 hr. at 95° C.)[2] approximately equal amounts of glucose and fructose together with some unhydrolysed disaccharide were detected on paper chromatograms. When the acid solution was heated for only 15 min., conditions which completely cleave furanosides, no detectable hydrolysis occurred. On paper chromatograms developed severally with the organic layers of mixtures of *n*-butanol, ethanol, water (40 : 11 : 19); pyridine, ethyl acetate, water (1 : 2 : 2) and ethyl acetate, acetic acid, water (9 : 2 : 2) the sugar was chromatographically identical to authentic leucrose. This identity was maintained on ionophoretograms run in borate buffer. The sugar was reducing to silver nitrate spray[5] and gave a positive test for ketose with *p*-anisidine[6]. With urea-phosphoric acid spray[7] it gave the grey-brown colour which is typical of leucrose[2] but in marked contrast to the bright-blue colour given by free fructose and acid labile fructose-containing oligosaccharides. Similarly a positive ketose test was obtained with naphthoresorcinol and resorcinol sprays only when they were strongly acid[8]. With aniline diphenylamine spray[9] both the sugar and authentic leucrose gave a greenish-blue colour compared with a yellow-orange colour for free fructose. The colour reaction obtained with this spray is to be expected if leucrose has the structure assigned to it with the glycosyl linkage joined to the fourth carbon from the reducing carbon of the molecule[9] (that is, carbon 5 of fructopyranose).

By the Shaffer and Hartmann[10] cuprimetric method the sugar had a reducing value of 46 per cent of that of fructose. This reducing value was unchanged after treatment with alkaline hypoiodite[11], showing that the reducing moiety of the sugar was fructose. Finally, the infra-red spectrum of the sugar was identical to that of leucrose and its m.p. (156–157° C.) was not depressed by authentic leucrose (156–158°C.)[2].

The mother liquors from the crystallization contained, in addition to leucrose, a second disaccharide which gave a blue ketose colour with urea-phosphoric acid. This sugar appeared to be chromatographically similar to the second disaccharide which is present in *Leuconostoc* cultures. Attempts are being made to isolate and identify it.

It has been suggested that leucrose formation represents some intermediate step in dextran synthesis[1]. This has been queried by Barker and Bourne[12] who suggest that leucrose synthesis, if due to dextransucrase activity, is the result of a side reaction. Such a reaction could arise from the ability of fructose to act as an alternative glucosyl acceptor in dextran synthesis. Although leucrose has been produced by the action of dextransucrase, the preparations used have been neither highly purified nor necessarily free from other carbohydrate-synthesizing enzymes. The isolation of leucrose from *S. bovis* does offer further, indirect, evidence that its formation is due to dextransucrase activity. First, with *S. bovis*, dextran is only produced from sucrose in the presence of abundant carbon dioxide[3,4], although the organisms grow vigorously in sucrose in an atmosphere almost free of carbon dioxide. The reducing disaccharides were only detected in the cultures when they were producing dextran. Secondly, the rate of dextran formation can be controlled to some extent by buffering the culture, when the disaccharide concentration increases as the rate of dextran production rises[3].

The specimen of leucrose was kindly supplied by Dr. F. H. Stodola, U.S. Dept. of Agriculture; and the infra-red spectra were prepared by Dr. S. A. Barker of the University of Birmingham. This work was initiated (R. W. B.) at the Plant Chemistry Laboratory, Palmerston North, New Zealand and completed as part of a programme supported by the Department of Scientific and Industrial Research.

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PHYSIOLOGY

Neuromuscular Blocking Action of some Antibiotics

CURARE-LIKE effects due to streptomycin and neomycin have been reported[1–3]. These two antibiotics have been shown to be capable of exerting a curariform block of the neuromuscular transmission[2–4]. One of us (G.B.) observed that some patients under heavy antibiotic treatment were more sensitive to

Table 1. PARALYSING ACTIVITY OF *d*-TUBOCURARINE CHLORIDE AND DECAMETHONIUM BROMIDE IN RABBITS TREATED WITH ANTIBIOTICS.

Antibiotic	Dose mgm./kgm.	Curarizing drug	Dose μgm./kgm.	Interval between the two treatments (min.)	Animals with partial paralysis/ treated animals*	Animals with total paralysis/ treated animals†	Dead animals/ treated animals
Control	—	*d*-tubocurare	120	—	14/21	0/21	0/21
Streptomycin ...	50	,,	120	3–11	5/5	3/5	0/5
Streptomycin ...	25	,,	120	10	1/2	0/2	0/2
Chloramphenicol succinate ...	100	,,	120	8	5/9	1/9	0/9
Control	—	,,	125	—	18/20	3/20	0/20
Tetracycline ...	25	,,	125	3	7/7	6/7	2/7
Penicillin	100	,,	125	3	9/9	1/9	0/9
Control	—	Decamethonium bromide	100	—	3/5	0/5	0/5
Streptomycin ...	50	,,	100	5	6/6	0/6	0/6

* Partial paralysis means neuromuscular insufficiency which, however, allows the animals to resume quickly the normal standing-up position after they have been put in the lateral position.
† Total paralysis is a severer neuromuscular insufficiency in which the animals are unable to resume the normal position.

the muscular relaxant action of *d*-tubocurarine. We have therefore begun to study the influence exerted by the most widely used antibiotics on the sensitivity of rabbits to the paralysing activity of curarizing drugs.

The antibiotic drugs so far tested include : streptomycin sulphate, tetracycline, chloramphenicol succinate and benzyl sodium penicillin. The curarizing drugs were *d*-tubocurarine chloride and decamethonium bromide (C_{10}). All drugs were rapidly injected into the marginal vein of the rabbit's ear. The results obtained are shown in Table 1.

Streptomycin and tetracycline increase the curarizing effect of *d*-tubocurarine while the other two do not. Streptomycin did not affect the activity of decamethonium bromide under the experimental conditions we employed. However, if streptomycin is administered to rabbits which have just recovered from paralysis induced by decamethonium bromide it re-induces the muscular paralysis. A similar experiment was tried with *d*-tubocurare and chloramphenicol succinate, but the results were negative.

This work is now being extended to other antibiotics and paralysing drugs. The results will be published in detail elsewhere.

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Inositol Concentration in the Cerebrospinal and Ocular Fluids and Tissues of the Fœtal and Adult Sheep

In the adult ewe the concentrations of free meso-inositol in the cerebrospinal fluid and aqueous humour are similar and exceed several-fold the concentration present in the plasma of the same animal[1]. It was of interest to examine this relationship in the fœtus since characteristically the concentration of inositol in fœtal plasma is greater than in that of the mother[2].

Welsh mountain sheep of known conceptual age were used; in this breed, term is at the 145–147th day. In all cases the cerebrospinal fluid was obtained from the cisterna magna. Determination of the vitreous humour concentration was carried out after filtration through glass wool. The fluids and tissues were removed as rapidly as possible after death and estimated for inositol by the microbiological assay method[3].

Krause and Weekers[4], and later Van Heyningen[5] showed that the lens was a tissue comparatively rich in inositol. In this series of observations the values obtained by Van Heyningen in adult sheep lens were confirmed and extended to include data on the fœtal and neonatal lens. It will be seen from Table 1 that free inositol forms a major part of the total inositol present in the adult lens; the total inositol concentration in the fœtal lens is considerably less than that present in the adult. In the fœtus no correlation of concentration with fœtal age was apparent. By the 2nd and 10th day of neonatal life the free inositol in the lens had risen to 93 and 146 mgm./100 gm. moist tissue, representing 99 and 79 per cent of the total inositol respectively. In contrast to the lens, the disparity between the total inositol in the optic nerve of the adult and fœtus is not so great; the mean concentrations were 335 mgm./100 gm. moist tissue (range, 280–440, six observations) and 245 mgm./100 gm. moist tissue (range, 170–290, five observations) respectively.

Table 1. Inositol Concentration in Sheep Lenses (mgm. /100 gm. Moist Tissue)

	Free		Total	
	Mean	Range	Mean	Range
Fœtal	—	—	57 (6)	50-60
Adult ..	487 (5)	360-740	500 (6)	340-940

Figures in parentheses refer to number of observations.

It will be seen from Table 2 that in spite of the high concentration of inositol present in the fœtal plasma, the concentration in the cerebrospinal fluid is correspondingly elevated, such that the cerebrospinal fluid/plasma ratio of the fœtus and the lamb resembles that of the adult. The concentrations in the fœtal aqueous humour, however, are similar to those of the plasma and only attain an aqueous humour/plasma ratio comparable to the adult in late fœtal life or shortly after birth.

Table 2. Free Inositol Concentration in Plasma, Cerebrospinal Fluid (C.S.F.) and Ocular Fluids of the Sheep (mgm./100 ml.)

	Fœtal or neonatal age (days)	Plasma	C.S.F.	A.H.	V.H.
Fœtus	94	20·4	166·0	27·8	—
	113	25·4	83·6	—	—
	127	22·4	78·3	24·5	27·5
	131	18·1	71·4	17·7	20·2
	132	13·3	66·1	24·3	13·4
	138	11·2	70·1	22·3	14·2
	142	11·0	52·6	13·5	13·1
	145	4·1	44·6	10·4	10·4
Lamb	2	4·0	38·6	8·8	16·7
	2	2·4	40·6	11·2	24·3
	3	2·5	21·4	6·2	—
	5	3·8	22·8	18·7	—
	10	2·5	16·0	17·1	15·2
	15	1·6	—	7·7	—
Adult	Range	0·44–5·8	5·3–21·5	6·4–20·6	7·7–19·0
	Mean	1·28 (29)	9·11 (26)	10·67 (29)	10·74 (8)

Figures in parentheses refer to number of observations.

The concentration in the vitreous humour, in both the adult and the fœtus, is similar to the concentration present in the respective samples of aqueous humour. In the adult, the combined inositol in the vitreous humour amounted to a mean of 13·8 per cent of the total inositol present (seven observations).

A possible interpretation of these results is that the secretory processes responsible for the formation of cerebrospinal fluid and aqueous humour have a different developmental time course. Flexner[6], in studies on the formation of cerebrospinal fluid in the fœtal pig, concluded that up to the first third of gestation the formation was one of diffusion and thereafter one of secretion. A difference in the degree of development of the blood-cerebrospinal fluid and blood-aqueous humour barriers towards *p*-amino-hippurate was observed by Davson[7] in the rabbit six weeks after birth. It is suggested, in view of the inositol concentrations, that an analogous development of the secretory processes responsible for the formation of these two extracellular fluids takes place. Thus, in the sheep fœtus, a secretory process for the formation of cerebrospinal fluid would appear to be established by 94 days, whereas in the aqueous humour the change-over from a plasma diffusate to a secretion is either delayed until birth or that the rate of turnover, due to a less efficient

blood-aqueous barrier, is so fast as to mask the secretory activity.

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Influence of Dietary Protein Percentage on Growth of Wool

As with other forms of animal production, it is a common experience that growth of wool is affected by nutrition and the quantitative relation between such growth and intake of food has been studied experimentally[1,2].

Early investigators stressed the high cystine content of wool, and suggested that the nutritive value of pastures for growth of wool depended on their ability to supply this amino-acid[3,4]. Marston[5] elaborated the theory that the rate of growth of wool is determined principally by the dietary supply of essential amino-acids, subject to competing demands on this supply. This view of the mechanism by which nutrition influences the rate of growth of wool has been widely accepted despite some earlier evidence to the contrary[6,7].

Results of recent experiments at this Laboratory indicate that growth of wool is independent of the dietary protein percentage over a wide range for diets fed both at maintenance and *ad libitum* levels of intake. Pelleted diets ranging from 7·5 to 29 per cent crude protein were prepared by varying the proportions of peanut meal and maize in the concentrate and the proportions of lucerne and wheaten chaff in the roughage. An additional diet was used in which the concentrate comprised a mixture of wheat, oats, linseed meal and coconut meal. The diets all contained 50 per cent roughage and 50 per cent concentrate and were approximately equal in net energy content as judged by published starch equivalent values for the constituent feed stuffs.

Growth of wool was measured at 4 weekly intervals by clipping 10 × 10 cm. midside sample areas defined by tattoo lines. The relation between the sample and total growth was determined for each sheep over a 12-week period during the experiment (period 2). It has been found that the ratio of total to midside growth is not affected by the level of feeding[2]. The wool samples were extracted successively with ether and water to remove wool wax and suint and the oven dry weights obtained. The crude protein content (N × 6·25) of the diets was determined by Kjeldahl's method on aliquot samples of feed.

Thirty-six 2-year old medium-wool Merino ewes housed in individual pens were fed 500 gm. daily of one diet prior to being divided at random into 4 groups, and fed *ad libitum* diets of different protein percentage. Intakes of the same diets were reduced again to 500 gm. per day for a further period. Afterwards the sheep were all again fed one diet prior to being divided into four different groups and fed another series of diets. The sequence of experimental treatments and results are shown in Table 1. The intake and growth data for periods 2 and 3 are for the latter 8 weeks of these periods to allow some adjustment to occur to the changes in feed intake at the beginning of these periods. Intakes of 500 gm. per day were sufficient to maintain the sheep in average body condition. No differences in body-weight change were observed between the groups on diets of different protein content at this feed intake. On *ad libitum* intakes only slight differences were observed in the rates of body-weight increase between the different diets. This suggests that diets were in fact approximately isocaloric in net energy.

Table 1. Wool Growth, Feed Intake, Crude Protein (per cent) of Diet and Efficiency of Protein Conversion into Wool

Period	Duration (weeks)	Group	Ration	Feed intake (gm./day)	Crude protein (per cent	Wool growth (gm./day)	Efficiency* (per cent)
1	8	I	*F*6	509	16·9	4·90	5·7
		II	*F*6	517	16·9	4·40	5·0
		III	*F*6	507	16·9	4·81	5·6
		IV	*F*6	508	16·9	4·58	5·3
2	12	I	*F*6	1,553	18·6	12·46	4·4
		II	*F*11	1,389	18·5	11·54	4·9
		III	*F*12	1,382	24·0	12·54	3·8
		IV	*F*13	1,389	29·3	12·27	3·2
3	12	I	*F*6	499	18·4	6·38	6·9
		II	*F*11	500	18·3	6·43	7·0
		III	*F*12	500	24·5	6·89	5·7
		IV	*F*13	500	29·5	7·33	5·0
4	8	I	*F*11	500	18·1	5·79	6·4
		II	*F*11	500	18·1	5·53	6·1
		III	*F*11	500	18·1	5·89	6·5
		IV	*F*11	500	18·1	6·03	6·7
5	12	V	*F*16	447	7·5	5·19	15·8
		VI	*F*15	491	11·2	4·65	8·4
		VII	*F*14	500	13·6	4·88	7·7
		VIII	*F*11	495	17·2	4·93	5·7

* Efficiency is expressed as (gm. clean dry wool)/(gm. crude protein intake) × 100.

The effect of increasing the intake of food of the sheep is shown by a comparison of the growth of wool in period 2 with that for the other periods. Comparison between periods also shows the existence of a seasonal trend in growth of wool[2]. The experiment commenced on August 2, 1957, and finished a year later, midsummer occurring in period 2.

Within any period there were no statistically significant differences in growth of wool between the groups fed diets of different protein content. The commonly observed growth response to increasing intake of food cannot therefore be attributed to an increasing dietary supply of amino-acids and must be wholly due to an increased energy supply when diets containing more than 8 per cent crude protein (on a dry matter basis) are fed. It must be expected that with diets of lower protein content a point must be reached when the supply of amino-acids is insufficient for wool synthesis. However it is not known whether this point is reached before protein deficiency interferes with the digestive function of the rumen and thereby with the availability of energy from the diet.

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A New Trichothecin-like Antifungal Antibiotic

In a screening programme for antibiotic effects of Basidiomycetes we found a strain which inhibited *Candida albicans*. The antifungal substance was produced by this strain in surface and submerged culture in a medium containing peptone, glucose, inorganic salts and aneurin. The substance for which we provisionally propose the name 'antibiotic-*T*' was easily extracted from the fermentation liquor by most of the usual solvents. After extraction with benzene and evaporation of the solvent the residue became crystalline within a few days. Recrystallization twice from methyl alcohol gave pure crystals (prisms), melting point 126°C., $[\alpha]_D^{20}$ +13·5°, *c.* 1 in chloroform. No ultra-violet absorption characteristic of antifungal antibiotics of the polyene type was found. The antibiotic contains no halogen, sulphur or nitrogen. Micro-analyses: found (per cent): carbon, 68·51; hydrogen, 7·6; and oxygen, 25·0. The substance is very slightly soluble in hot water and gives a neutral solution; it is soluble in alcohols and sunflower oil and readily soluble in non-polar solvents. Its solution in water is stable for two months, is thermo-stable at its boiling point, but is inactivated at *p*H 12 within a few hours.

From the chemical and biological data available antibiotic-*T* seems to be very similar to the antifungal antibiotic trichothecin[1,2]. The two materials have however different R_F values in paper chromatography tests. A further difference between the two antibiotics is the negative 2:4-dinitriphenylhydrazine test of the new antibiotic. The infra-red absorption spectra of the two substances (Fig. 1) are very similar antibiotic-*T* however has no band at 1686 cm.$^{-1}$ and therefore presumably contains no ketone group.

Freeman *et al.*[1] found trichothecin to be an ester, the components of which are isocrotonic acid and a ketonic alcohol, trichothecolone. The structure of the latter was given by Freeman recently[3]. The new antibiotic was hydrolysed with a cold methanolic solution of potassium hydroxide. The acid component obtained seems to be identical with the acid component of trichothecin by the paper chromatography test.

The new alcohol component of hydrolysis has a m.p. 152°C. on recrystallization from a mixture of benzene and light petroleum. The hydroxyl content was 6·82 per cent, which corresponds to a molecular weight of 250, if one OH group is present per molecule.

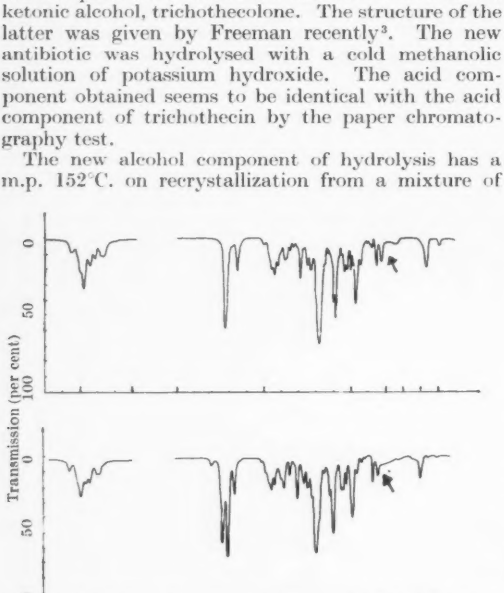

Fig. 1. Infra-red absorption spectra 1·6 per cent solutions of (top) antibiotic-*T* and (bottom) trichothecin in carbon tetrachloride. The region of solvent absorption is marked with an arrow.

Table 1.

	Days of incubation				
	1	2	5	8	14
	Inhibitory concentrations, μgm./ml.				
Candida albicans	4·0	11·0	45·0	90·0	
Saccharomyces cerevisiæ ...	5·0	10·0	20·0	37·0	
Cryptococcus neoformans ...		2·5	10·0	15·5	40·0
Aspergillus niger		100·0			
Trichophyton mentagrophytes		2·5	40·0	90·0	
Epidermophyton inguinale ...				4·0	20·0
Microsporon audouini ...			1·2	2·5	5·0

The fungi were seeded on the surface of agar slants containing various antibiotic concentrations. The tubes were incubated at 25°C. The figures indicate mean total inhibition on a given day of incubation.

The antifungal effects of antibiotic-*T* (Table 1) are similar to those of trichothecin[2], though somewhat weaker in the case of most of the fungi examined. The effect is fungistatic. Bacteria are not inhibited at a concentration of less than 500 μgm./ml. The LD_{50} in mice after intraperitoneal administration in a gum arabic suspension is 810 mgm./kgm. and after administration *per os* more than 1000 mgm./kgm. Doses smaller than the LD_{50} produce transient collapse, ataxia, paralysis of the hind legs and sometimes convulsions, symptoms which are analogous to those observed by Freeman with trichothecin[2]. No antibiotic was found in the blood after administration by various routes of 50–200 mgm./kgm. to mice and rats. The antibiotic is inactivated when incubated with blood at 37°C. for 24–48 hr. It is effective in reducing the yeast cells found in fæces of mice fed a standard diet containing terramycin, after the administration of 250 mgm./kgm. by mouth with a sonde. Reddening and irritation is caused when the antibiotics applied to the skin of guinea pigs, rabbits and human beings; the alcohol component of the new antibiotic does not have this effect.

The antibiotic isolated seems to differ from those mentioned in the literature but is very similar to trichothecin. The antifungal antibiotic cephalothecin[4], perhaps similar to trichothecin, contains carbon, hydrogen and oxygen and decomposes at 124–26°C. Antibiotic-*T* melts without decomposition at this temperature.

We wish to thank S. Holly for the infra-red absorption data.

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Phenazine Di-N-Oxide as a Carcinostatic Agent

Phenazine di-*N*-oxide has been found to be a carcinostatic agent for the Ehrlich ascites tumour. More than 90 per cent of tumour-bearing animals treated with this compound intraperitoneally survived 30 days or more, and were then free of tumours as

compared with an average 13-day survival of the untreated control group. A comparison of this agent with other drugs active against this tumour reveals that 6-mercaptopurine, administered intraperitoneally[1], or *N*-methylformamide, given orally[2], extended mean survival time by 25–100 per cent, but that all animals died with ascites tumour. Other phenazine compounds, like the dye janus green *B*[3] have been reported to have activity against a transplanted mouse tumour, but only at toxic levels.

The compound was made by oxidation of phenazine[4]. Swiss-Webster mice were inoculated with 0·1 ml. (10–16 × 10⁶ cells) of undiluted ascitic fluid from a donor mouse bearing a 7-day-old ascites tumour. 24–48 hr. later the drug was administered intraperitoneally or subcutaneously as a suspension in 1 per cent carboxymethylcellulose at a dose of 50–75 mgm./kgm. The drugs were given once daily for five consecutive days. Control animals were similarly treated with the exception that only the suspending agent without drug was injected. At the end of thirty days all surviving animals were killed and examined for tumours.

Table 1. Effect of Phenazine-di-*N*-oxide on Survival Time of Mice with Ehrlich Ascites Tumour.

Drug	Number of Animals	Weight at day: 7	14	21	Mean survival time*	Range (days)	Number of survivals after 30 days
Controls	20	20·1	22·2	27·6	13·3 ± 2·0	10–17	0
Phenazine-di-*N*-oxide intraperitoneally 50–75 mgm./kgm.	50	19·5	19·2	19·9	One animal dead on day 16, 19, 21, 23	—	46
Phenazine-di-*N*-oxide subcutaneously 50 mgm./kgm.	10	20·7	21·7	25·0	22·5 ± 2·7	19–28	2
Phenazine intraperitoneally 75 mgm./kgm.	10	19·6	21·1	25·9	15·3 ± 1·8	12–17	2
2,3-dimethyl quinoxaline di-*N*-oxide intraperitoneally 50 mgm./kgm.	10	18·1	22·2	30·2	12·4 ± 3·8	8–17	1

* Mean survival time calculated exclusive of 30 day survivors.

$$S.D. = \sqrt{\frac{(x - \bar{x})^2}{n-1}}$$

The results for the several agents are shown in Table 1. After intraperitoneal treatment 46 out of 50 mice survived 30 days and were then grossly free of tumours except in 2 cases where there were subcutaneous solid tumours. When the drug was administered subcutaneously the average survival was 22 days as compared with 13 days for the controls, and only 2 of the animals survived to 30 days without the appearance of tumour. This suggests that the intraperitoneal effect was in part local. Phenazine, itself, and 2, 3-dimethylquinoxaline di-N-oxide, a compound with structure similar to the active phenazine-di-N-oxide, were devoid of activity. In other experiments with the di-N-oxide now in progress a few subcutaneous solid tumours have been noted in animals surviving over 40 days. As a result the compound is being tested for carcinogenic activity also.

Phenazine-di-N-oxide is a simple compound; it is apparently not an anti-metabolite and it is not a chelating agent. The nature of the inhibition is being investigated, but the presence of the potentially reducible N→O groups in the 9,10 positions of the molecule suggests that respiration may be depressed through interference with electron transfer.

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Thiamine-sparing Action of Sorbitol in Rats and Mice

Deficiency of thiamine may be prevented in rats if they are given sorbitol. Administration of sorbitol to deficient rats cures the deficiency; withdrawal of the sorbitol leads to deficiency[1]. All these results have now been found also in mice (Fig. 1). Mice, like rats, also showed an enlarged cæcum when they were fed diets with sorbitol (Table 1).

About 1 in 8 of the mice did not respond to sorbitol in these ways. On diets deficient in thiamine, they lost weight and ultimately died, even though sorbitol was present in their diets. We found that these mice which did not respond showed no enlargement of the cæcum, and developed bradycardia. This is a characteristic feature of thiamine deficiency in rats, although so far as we know it has not been described in mice.

With rats, we have attempted to assess the 'thiamine equivalent' of sorbitol. First, we compared the growth of rats receiving 15 per cent sorbitol in their diets and no thiamine, with that of rats receiving 15 per cent glucose and graded doses of thiamine. The rats receiving 8 μgm. thiamine daily grew rather more slowly than those receiving sorbitol, whereas those receiving 12 μgm. daily grew faster. We can say then that 15 per cent sorbitol in the conditions of our experiments is equivalent to the administration of something like 10 μgm. thiamine daily.

Secondly, we have compared the stores of thiamine in the tissues of rats fed sorbitol and no thiamine, with those of rats fed glucose and graded doses of thiamine. We determined the thiamine by the thiochrome method in brain, liver and gastrocnemius muscle. By interpolation, we calculated that the rats receiving sorbitol had stores of thiamine as large

Table 1. Effect of Sorbitol on Weight of Alimentary Canal in Mice.

Organ	Wet weight (gm.) Diet without sorbitol (*A*)	Diet with sorbitol (*B*)	Ratio *B/A*
Small intestine	1·18	1·55	1·3
Small intestine with contents	1·57	1·77	1·1
Cæcum	0·08	0·28	3·5
Cæcum with contents ...	0·24	0·99	4·1
Average weight of mice (number of mice) ...	29 (4)	27·2 (9)	

as they would have obtained from ingesting about 9 μgm. thiamine daily.

Thirdly, we have roughly determined the thiamine equivalent of a single dose of sorbitol given to thiamine-deficient rats. The heart-rate of the rats was measured daily. When it had fallen from the normal 450 beats a minute to less than 300, we gave one dose of 1 gm. of sorbitol. This restored the heart-rate to normal for 12 days. A dose of 10 μgm. thiamine restored the heart-rate for 10 days.

In our earlier communication, we gave reasons for believing that the thiamine-sparing action of sorbitol was brought about by a synthesis of thiamine in the gut. The question then arises whether the vitamin was absorbed in the gut, immediately after synthesis, or whether it was excreted in the fæces and was available only after the animal had eaten its fæces.

As is well known, coprophagy in rats is not prevented by simple means such as housing the animals on grids, as we have done in all our experiments. We therefore attempted to devise a procedure which

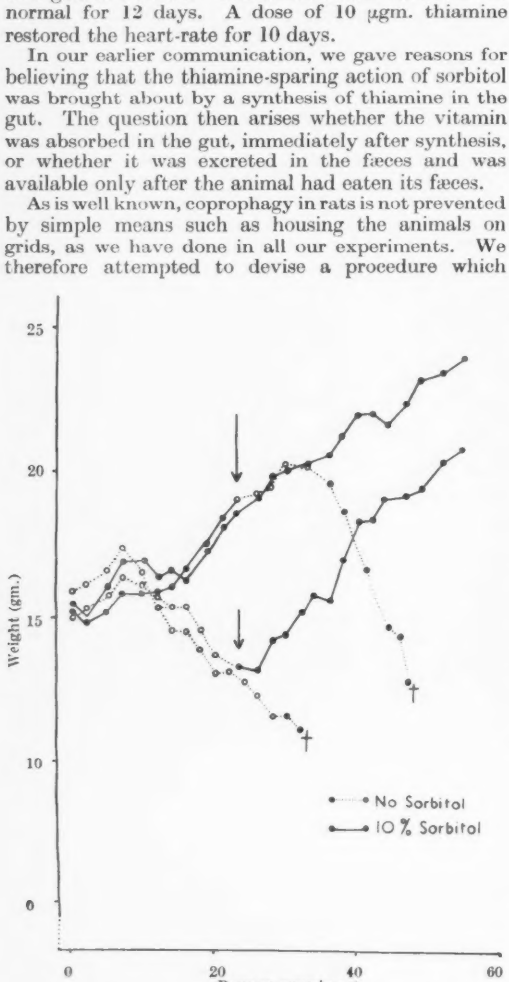

Fig. 1. Effect of change-over of diet. Growth of 4 mice on diets deficient in thiamine; one pair was initially given no sorbitol and one pair given 10 per cent sorbitol. At the times indicated, the diet of one mouse of each pair was changed to that of the other pair. ○.....○, Diet with 60 per cent sucrose; ●———●, diet with 10 per cent sorbitol and 50 per cent sucrose.

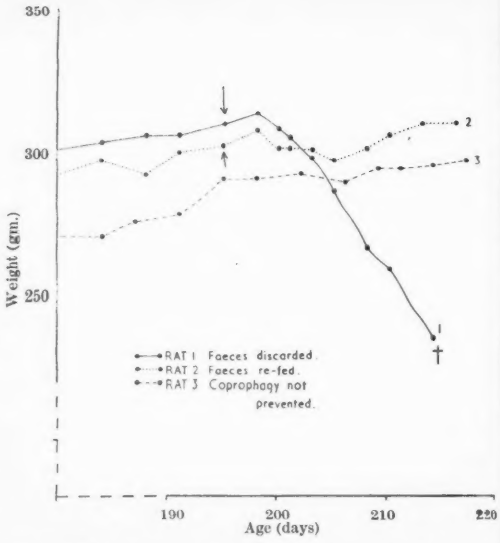

Fig. 2. Role of coprophagy in thiamine-sparing action of sorbitol. 3 rats fed thiamine-free diet containing 10 per cent sorbitol and 50 per cent sucrose for about six months from weaning. At times indicated, devices to prevent coprophagy were fitted to rats 1 and 2. ●———●, Rat 1, fæces discarded; ●.....●, rat 2, fæces collected each day and fed to animal following day; ● - - - - - - - ●, rat 3, coprophagy not prevented.

would prevent coprophagy. In the first series of experiments, when we thought we had achieved this, sorbitol still showed its thiamine-sparing action, and we reported that coprophagy was not a necessary feature of the action of sorbitol[2]. Later, we were able quite definitely to prevent coprophagy by a recently published technique[3]. As a result, we can now say that most of the thiamine synthesized in the gut under the influence of sorbitol only becomes available to the rat after coprophagy. If coprophagy is prevented, rats fed sorbitol without thiamine lose weight and die of thiamine deficiency. If the fæces collected in these experiments are re-fed to the rats, they grow in the usual way (Fig. 2). These fæces from sorbitol-fed rats also prevent the development of deficiency in rats fed on glucose.

By further experiments of this sort, we found that the thiamine-deficient rats fed on glucose also excrete a small amount of thiamine in the fæces. Though very little, it is nevertheless enough to prolong the life of such rats for a short while. If coprophagy is prevented, death from thiamine deficiency is accelerated.

Measurement of the heart-rate confirmed that the effects of allowing or preventing coprophagy were due specifically to thiamine. The prevention of coprophagy in rats fed on sorbitol led not only to loss of weight but also to the development of bradycardia. Administration of thiamine, or removing the device which prevented coprophagy, led to a restoration of the heart-rate.

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Effect of Sorbitol on the Urinary Excretion of some B Vitamins in Man

THE inclusion of sorbitol in the diets of rats makes them able to survive and grow in the absence of dietary sources of B vitamins[1]. It is likely that the sorbitol acts by increasing the synthesis of these vitamins in the alimentary canal. We have investigated the possibility that sorbitol similarly increases synthesis in man. We have done this by determining the urinary output of three vitamins in a male subject aged 27 (J.D.W.) before, during and after the ingestion of sorbitol.

Urine was collected for exactly twelve hours daily, for four days a week, over a period of 26 weeks. From the beginning of the fifth week to the end of the thirteenth week sorbitol was taken. The intention was to begin with 20 gm. daily for two or three days, and to increase it within two weeks to 50 gm. daily. However, occasional mild diarrhœa led to reduction of the dose from time to time, so that the daily intake varied between 20 and 40 gm. during the nine weeks of supplementation. The vitamins investigated were thiamine, riboflavin and nicotinic acid. We measured the excretion of the first two as such, and of the major excretory product of the third, N^1-methylnicotinamide. Fluorometric methods were used for all estimations; that of Mawson and Thompson for thiamine[2], of Slater and Morell for riboflavin[3] and of Carpenter and Kodicek for N^1-methylnicotinamide[4].

The subject kept a weighed record of all the food he ate during the 26 weeks of experiment; the nutrients therein were calculated from food tables. There was little variation in the intake of any nutrients, including the three vitamins under study; in particular, there was no significant difference in intake between the periods before, during and after the consumption of the sorbitol (Table 1).

The excretion of the vitamins fluctuated considerably (Fig. 1). The ingestion of sorbitol produced no effect during the first week or more, but then there was a distinct increase of excretion of all three vitamins. When the sorbitol was stopped, there was again no change for a week or more. After this, the excretion of thiamine and riboflavin fell, but the excretion of N^1-methylnicotinamide remained at the level it had reached with sorbitol. It is possible that this might also have shown a fall if we had continued with the study for a longer period. For statistical calculation, it seemed reasonable to omit a transition period of three weeks following the beginning or end of sorbitol administration (Table 2). We then find that the increases in excretion of all three vitamins with sorbitol, and the decreases in excretion of thiamine and riboflavin after sorbitol, are significant at levels of 1 per cent or less.

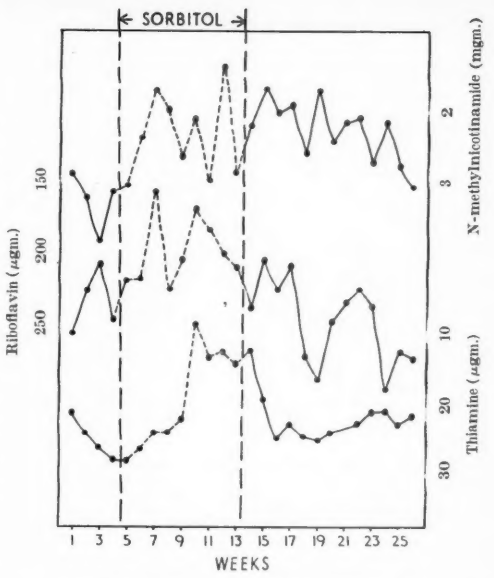

Fig. 1. Effect of sorbitol on urinary excretion of B vitamins. Urinary excretion of B vitamins before, during and after ingestion of 20–40 gm. sorbitol daily. Values are mean 12-hourly excretions for 4 days weekly.

Table 1. AVERAGE DAILY INTAKE OF CALORIES AND NUTRIENTS.

	Weeks 1–4 (before sorbitol)	Weeks 5–13 (during sorbitol)	Weeks 14–26 (after sorbitol)
Calories	2420	2290	2270
Carbohydrate (gm.)...	290	285	285
Fat (gm.)	103	97	94
Thiamine (mgm.) ...	1·1	1·1	1·05
Riboflavin (mgm.) ...	2·1	2·0	2·0
Nicotinic acid (mgm.)	14·1	13·6	13·7

Table 2. VITAMIN EXCRETION IN URINE. AVERAGE VALUES FOR 12-HR. PERIODS.

Vitamin	Weeks 1–4 (before sorbitol)	Weeks 8–13 (during sorbitol)	Weeks 17–26 (after sorbitol)	Significance (*P*)	
	a	*b*	*c*	*b–a*	*b–c*
Thiamine (μgm.) ...	14·7	23·9	16·6	0·001	0·001
Riboflavin (μgm.)...	172	209	147	0·01	0·001
N^1-methyl-nicotinamide (mgm.)	2·34	2·83	2·81	0·002	0·25 (N.S.)

Sorbitol, 20–40 gm. daily, was taken during 5th to 13th weeks of the experiment. Urine was collected for 12 hr. each day from Monday to Thursday.

The effect of sorbitol on increasing the excretion of vitamins might be due either to increased synthesis with subsequent absorption, or to enhanced absorption of the vitamins already present in the diet. The latter mechanism, it has been suggested, occurs with vitamin B_{12} (ref. 5). However, we already know from our animal experiments that sorbitol induces a synthesis of B vitamins. It is also known that vitamins synthesized in the human gut may be absorbed. We are inclined therefore to believe that our results are due to increased synthesis of three of the vitamins which are then absorbed. The delay in the effect of sorbitol on the excretion of these vitamins would support the suggestion that the effect is on microbial synthesis rather than on absorption. The final decision, however, must depend on further investigation.

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RADIOBIOLOGY

Biogeochemical Enrichment of Fission Products

Prospecting for radioactive minerals has gone on for some years in southern Sweden, and areas of higher radioactivity have been subjected to a closer examination. During the course of this survey, samples of different plants were also analyzed with the view of discovering whether biogeochemical prospecting methods could be used or not. It was found that the ash of most plant samples possessed a considerably higher radioactivity than the soils upon which they were growing. This observation led to a closer examination of the distribution of plant radioactivity within some districts in southern Sweden. The districts were chosen to cover not only different rock and soil types but also different topographic sites. The plants collected included the following species: *Picea abies*, *Pinus silvatica* *Juniperus communis*, *Fagus silvatica*, *Quercus robur*, *Calluna vulgaris*, *Vaccinium myrtillus*, *V. vitis-idæa*, *Polytrichum*, and *Athyrium*.

Both Geiger counters and scintillometers were used during the initial stage of the survey; but it was soon found convenient to concentrate mainly on β-activity measurements, since the γ-activity of the mineral soil often varies considerably.

The preliminary results of this survey of plant radioactivity demonstrate that, within each separate area, the ash of most of the plants examined showed about the same β-activity. Some plant samples gave, however, higher values than others. The highest values were obtained for needles, leaves, and for the twigs, whereas the wood of the trunks and the roots gave values corresponding to those of the mineral soil. In some cases the dead parts of the plants showed about the same radioactivity as the living parts, but in other cases a marked decrease in radioactivity was observed.

Table 1 gives the values hitherto obtained. The apparatus used was a Geiger counter type *DG*-2 (Detectron Co.). The most common rocks and soils of the region gave readings under field conditions from 0·025 to 0·050 mr./hr., marked differences being noted between metamorphic rocks of different origin. The ash samples were measured under laboratory conditions with a background of 0·025 mr./hr. In order to facilitate a comparison between the different samples, only the analyses of the ash of spruce twigs have been included in Table 1.

Additional measurements indicated that the plant

Table 1. Measurements of the Radioactivity of the Ash of Spruce Twigs from Hills (*A*) and Lowlands (*B*) in Southern and Western Sweden, Collected and Analysed in March and April 1959.

A.	3.	Uncovered mineral soil	0·030	mr./hr.	Ash	0·080	mr./hr.
	8.	"	"	0·025	"	0·150	"
	17.	"	"	0·035	"	0·080	"
	19.	"	"	0·040	"	0·150	"
	24.	"	"	0·030	"	0·105	"
	25.	"	"	0·030	"	0·115	"
	30.	"	"	0·050	"	0·150	"
	31.	"	"	0·030	"	0·060	"
	32.	"	"	0·030	"	0·110	"
	33.	"	"	0·030	"	0·110	"
	36.	"	"	0·030	"	0·120	"
	39.	"	"	0·025	"	0·060	"
	40.	"	"	0·040	"	0·060	"
	45.	"	"	0·035	"	0·075	"
	48.	"	"	0·035	"	0·075	"
B.	5.	"	"	0·025	"	0·050	"
	35.	"	"	0·025	"	0·045	"
	37.	"	"	0·030	"	0·060	"
	49.	"	"	0·030	"	0·085	"
	50.	"	"	0·035	"	0·055	"
	51.	"	"	0·035	"	0·090	"

radioactivity decreased with time more rapidly than could be expected if it were caused by natural radioactive elements only. Some samples were therefore subjected to γ-spectrometric analysis at the Swedish Research Institute for National Defense. It was found that the main part of the γ-activity is due to the presence of more long-lived fission products (zirconium+neobium)-95, cerium-141, and ruthenium-103. There is reason to believe that yttrium-91 and strontium-89 are present in about the same quantities as (zirconium plus neobium)-95, and that cæsium-137 and strontium-90 equal about 1/100 of the amount of (zirconium plus neobium)-95. The amount of natural radioactive elements is negligible compared with that of fall-out products. A comparison between the results of these γ-spectrometric analyses and the conclusion which can be drawn from the geological sites of the different samples is also consistent with low natural radioactivity as compared with that resulting from fall-out.

K. Löw and K. Edvarson report[1] that the main γ-activity of top-soil layer samples collected in some Swedish localities during the summer of 1958 is due to the presence of (zirconium plus neobium)-95 from fall-out during the first half of 1958. My measurements of the β-activity indicate no special enrichment in the top layer of the mineral soil, in the root, nor in the wood of the trunks of trees examined. On the contrary, there is a high increase of β-activity in the twigs, and especially in needles and leaves, as also in the *F*-layer of the soil profile. The figures upon which this report is based indicate furthermore that there is a higher concentration of fission products in the ash of plants grown closer to the coast; the same is the case for plants grown upon sides and summits of marked hills and mountains. The lowest values are obtained for flat terrains at larger distances from the sea. It is evident that this depends, to a great extent, on the amount and frequency of precipitation, both directly in the form of rain and snow and indirectly through the 'filtering' action of the vegetation upon low-striking clouds and mist. Detailed surveys are, however, necessary in order to discover the distribution pattern of these new elements in the biogeochemical cycles.

The ash of plant samples hitherto examined by me shows a 2–6 times greater β-activity than the top layer of the mineral soil, with an observed maximum of 16 times. One conclusion to be drawn from these figures is that it is not primarily the presence of fission products in the air, in the soils, or in the waters that constitutes the most direct danger for radioactive damage but rather the sometimes very high biogeochemical enrichment in plants and/or animals. This biogeochemical enrichment may give rise to a successive concentration along the plant generations of some of the long-lived fission products through a combination of the continuous supply from the air and the successive supply from decaying, radioactive plants or plant parts in the *F*-layer.

Prospecting for radioactive mineralized zones may be considerably disturbed by the presence of fission products enriched in plants or in the *F*-layer of the soil profile. Due consideration has therefore to be given to the distribution pattern of this fall-out radioactivity, especially if nuclear bomb tests are to proceed.

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Labelling of Rose Bengal with Iodine-131 by Radioactive Exchange

THE most widely used test for the chromoexcretive ability of the polygonal liver cells is the clearance test with rose bengal. The scope of the method was increased considerably by Taplin *et al*[1,2] who introduced the use of labelled rose bengal. The test achieved great diagnostic value in cases of obstructional and toxic damage. We have been able to improve the method for preparing rose bengal labelled with iodine–131.

The iodination of tetrachlorofluorescein is the normal method used for labelling rose bengal (tetrachlorotetraiodofluorescein). The iodination is carried with iodine in alkaline solution with iodine chloride[3]. The first method is inconvenient because of low yield and the second because it requires radioactive iodine chloride. We therefore applied the method of iodine exchange which we employed successfully for labelling of roentgen contrast media[4]. The method proved satisfactory for rose bengal as well. Yields of radioactivity up to 80 per cent were obtained.

For example 1 gm. of rose bengal (Bayer Lachema); 24 ml. of 1*N* acetate buffer solution, *p*H 5; 0·21 mgm. potassium iodide carrier, and 8·1 ml. of potassium iodide–131 solution (31 mc.) were heated to 80°C. under reflux on a water-bath for 12 hours. Rose bengal was precipitated after cooling by the addition of concentrated hydrochloric acid to *p*H 1, the precipitate filtrated through a Buchner funnel by suction and washed with cold water until the volume of the filtrate was 64 ml. The filtrate contained 9 per cent of the added radioactivity. The precipitate was dissolved in a slight excess of concentrated ammonia and again precipitated, filtered and washed. The recrystallization was repeated once more. The yield of rose bengal —^{131}I was 80 per cent with 78·8 per cent of the original radioactivity. The radioactivity was determined in liquid samples with a scintillation counter.

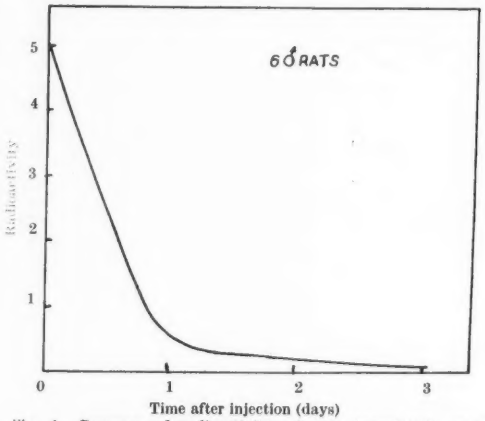

Fig. 1. Decrease of radioactivity of rose bengal-^{131}I after intravenous injection.

The biological properties of the product obtained by this method were tested. 6 rabbits were injected intravenously with 20 μc. of rose bengal –^{131}I, the radioactivity of the thyroid was 8 per cent higher than the activitity measured over the thigh under identical conditions. In a group of 6 rats the total decrease of radioactivity was determined after intravenous injection of 5 μc. of rose bengal –^{131}I per 200 gm. The results are given in Fig. 1. For this experiment the rats were put in a circular cage around which 6 Geiger-Müller counters were placed in order to measure the decrease in radioactivity. Counts were taken 0·5, 18, 24, 48 and 72 hours after injection. Fig. 1 shows that practically all the radioactivity is excreted within 72 hours.

The diagnostic applicability of the compound was tested first on 24 rabbits suffering from carbon tetrachloride poisoning and positive results were obtained within 24 hours with doses as low as 20 μgm./1 gm. given orally, and secondly on a group of 6 rabbits with a ligation of the common bile duct. The results with clinical cases were satisfactory.

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BIOLOGY

Immunological Distances among some Gallinaceous Birds

INFORMATION on phylogeny and systematics can be obtained from immunological relationships since red-cell antigens are gene-determined. To measure the immunological relationships between two species the following formula was used:

$$I.D. = \frac{1}{\sqrt{\frac{Oa}{Ea} \cdot \frac{Ob}{Eb}}},$$

where *Oa* and *Ob* are titres with homologous cells (using anti-*a* and anti-*b* sera), and *Ea* and *Eb* are titres with heterologous ones. This value is named 'immunological distance', because it will tend to increase as the biochemical relationship, that is the proportion of common antigens, decreases[1].

An immunological analysis of red-cell antigens of five species of gallinaceous birds has been carried out. These species were: domestic fowl (*Gallus domesticus*), guinea hen (*Numida meleagris*), turkey (*Meleagris gallopavo*), japanese quail (*Coturnix coturnix*) and ring-necked pheasant (*Phasianus colchicus*). Titres are given in Table 1. The immunological technique has

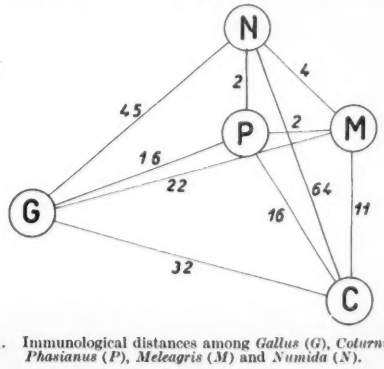

Fig. 1. Immunological distances among *Gallus* (*G*), *Coturnix* (*C*), *Phasianus* (*P*), *Meleagris* (*M*) and *Numida* (*N*).

Table 1.

Antiserum	Test cells				
	Meleagris	*Numida*	*Gallus*	*Corturnix*	*Phasianus*
Meleagris	1/1,280	1/1,280	1/80	1/640	1/1,280
Numida	1/320	1/5,120	1/40	1/20	1/1,280
Gallus	1/40	1/80	1/1,280	1/640	1/80
Coturnix	1/320	1/1,280	1/40	1/20,480	1/320
Phasianus	1/320	1/1,280	1/80	1/320	1/1,280

already been described[2]. Immunological distances obtained from this analysis are shown in Fig. 1.

According to this analysis, *Phasianus*, *Numida* and *Meleagris*, which, in Wetmore's classification[3] belong to three different families, have a close immunological affinity, while *Gallus* and *Coturnix*, which belong, with *Phasianus*, to the same family, are rather remote from one another and from all other species.

Yamashina[4], on the basis of cytological investigation, divided these five species into four groups, with *Phasianus* and *Meleagris* in the same group. Immunological affinity between *Meleagris* and *Numida* has been confirmed by chromatographic analysis[2].

On the basis of this analysis, the subdivision of these species in three families (Numididæ, Meleagrididæ and Phasianidæ) does not appear to be justified, and it seems preferable to place all these species in the family Phasianidæ, in agreement with Yamashina's cytological studies[5], Verheyen's morphological ones[6], and Sibley's electrophoretic analysis of egg-white proteins[7].

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Occurrence of Embryo Sac-like Structures in the Microsporangia of *Leptomeria billardierii* R.Br.

The pollen grains of certain liliaceous plants, for example *Hyacinthus* and *Ornithogalum* are known to give rise to embryo sac-like structures[1]. During the course of a study of the embryology of *Leptomeria acida*, *L. cunninghamii* and *L. billardierii* (Santalaceæ), I came across embryo sac-like structures arising directly from the microspore mother cells in the last named species—a phenomenon which is probably not yet recorded in any other angiosperm. Besides the microtome sections, acetocarmine squashes proved very useful for obtaining complete views of the 'embryo sacs'.

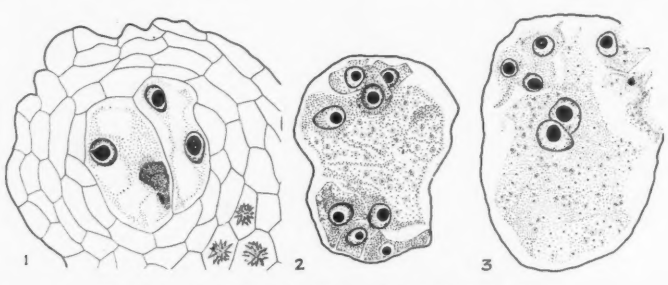
The development of the anther wall and differentiation of the sporogenous cells proceed as usual. While some of the sporogenous cells degenerate, others enlarge and become vacuolated. These undergo a nuclear division and the daughter nuclei are separated by the appearance of a large central vacuole (Fig. 1), although sometimes they may lie close to each other. The next two divisions result in an eight-nucleate stage with four nuclei at either pole. The nuclei of one of the quartets organize into the 'egg apparatus' and the upper polar nucleus, while those of the other into three 'antipodal cells' and the lower polar nucleus (Fig. 2). Thus, the sequence of development and the ultimate organization closely resemble that of an eight-nucleate female gametophyte. The similarity is further enhanced by the subsequent behaviour of the polar nuclei, which move to the centre of the sac and lie pressed to each other (Fig. 3). Due to the unilateral growth of the 'embryo sac' the 'antipodal cells' usually come to lie on one side (Fig. 3). Starch grains appear after the four-nucleate stage (Figs. 2, 3) and often mask the contents of the 'embryo sac'.

Several variations have been observed in the number of nuclei and their organization. A six-nucleate 'embryo sac' showed the egg apparatus, two polar nuclei and a single binucleolate antipodal cell. In another six-nucleate 'embryo sac', five nuclei were grouped in the centre while the sixth had migrated to one of the poles.

Due to lack of critical stages it could not be ascertained whether reduction divisions occur at all. At our request Mr. C. P. Roots made many fixations of buds from October to November (at two-hourly intervals during the month of November) but none of these showed any stage of meiosis.

Out of the large number of flowers examined none of the microsporangia contained normal pollen grains, while in the other two species (*L. acida* and *L. cunninghamii*) fertile pollen is produced in abundance.

In this connexion it may be mentioned that in *L. billardierii* the megaspore mother cell forms a dyad of which the lower cell gives rise to an eight-nucleate



Figs. 1–3. 'Embryo sacs'. Fig. 1. From a microtome section, others from squash preparations. Fig. 1. Anther lobe with bi-nucleate 'embryo sac'. Figs. 2, 3. Organized 'embryo sacs'; note the laterally situated 'antipodal cells' in Fig. 3 (× 480).

embryo sac. The polar nuclei fuse as usual and the development of the embryo and endosperm is comparable to other species of *Leptomeria*, although there is complete absence of pollen grains in the microsporangia and even on the stigma. The divisional stages leading to megaspore formation were not observed. It seems quite likely that this species is an apomict and the diplosporous embryo sac is diploid.

Whether the transformation of microspore mother cells into 'embryo sacs' is controlled by genes or due to physiological causes or both, is difficult to say. I should be most grateful if anyone could inform me of any similar cases.

I am indebted to Dr. B. M. Johri and Prof. P. Maheshwari for valuable suggestions, and to Dr. T. E. Burns and Mr. C. P. Roots of Launceston, Tasmania who very kindly supplied the *L. billardierii* material.

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Antibacterial Substances of Coniferous Seedlings at Different Stages of their Development

IT is well known, that the damping off of coniferous seedlings causes serious damage and in many cases complete destruction up to the appearance of the foliage. Once the cotyledons are fully developed and foliage leaves have failed to appear, complete destruction may be expected. Following the appearance of the foliage leaves the percentage of the damping off is greatly reduced or totally stopped. Nor does the disease appear when it could be expected in the presence of suitable conditions (high temperature, abundant moisture and excessive decomposing organic substances[1,2,3,4]). Consequently it may be assumed that in these two developmental phases there must exist such a difference in the plant substance which is closely connected with the cause of damping off.

Seedlings of pines (*Pinus silvestris* and *P. nigra*) were examined before and after the appearance on the foliage leaves and at the age of one year. Studies of antibiotical substances were made with the diffusion method. The substance was extracted with alcohol and chloroform and was examined on bouillon and glucose agar media. Test organisms were: *Micrococcus pyogenes* var. *aureus*, *Bac. cereus* var. *mycoides*, *Bac. megatherium*, *Proteus vulgaris*, *Serratia marcescens*, *Pseudomonas syringæ* var. *capsici*, *Escherichia coli*, *Fusarium oxysporum* var. *aurantiacum*, *F. moniliforme*, *Cladosporium herbarum*, *Botrytis cinerea*, *Rhizoctonia solani*, *Penicillium crustaceum* and *Gibberella fujikuroi*. The experiments were repeated with the *Fusarium oxysporum* and other fungi and bacteria isolated from dead seedlings.

On the basis of the results it is concluded that:

(1) The seedlings contain no antimicrobiotic substances before the appearance of the foliage leaves.

(2) The substance extracted from seedlings after appearance of foliage leaves, like the one-year plants, inhibits the Gram-positive bacteria.

(3) This substance has no antifungal effect, consequently offers no defence against the damping off fungi.

(4) In the case of Gram-negative bacteria there is no clear zone left.

The failure of the disease after the formation of the antibacterial substance suggests that the Gram-positive soil bacteria must have a certain role in the damping off of coniferous seedlings.

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ENTOMOLOGY

Effect of Insecticides on the Bodies of Nissl and Neurofibrillæ of the Locust, *Schistocerca gregaria*

IN a previous paper we demonstrated the Nissl bodies in the various developmental stages of *Schistocerca gregaria* as granules which are evenly distributed throughout the cytoplasm of the motor neurones of the thoracic ganglia.

In locusts treated with insecticides, the Nissl bodies tend to migrate towards the cell periphery and at the same time they are gradually reduced in number, until at the point of death only a few are left. The behaviour of the Nissl bodies differs from one insecticide to another.

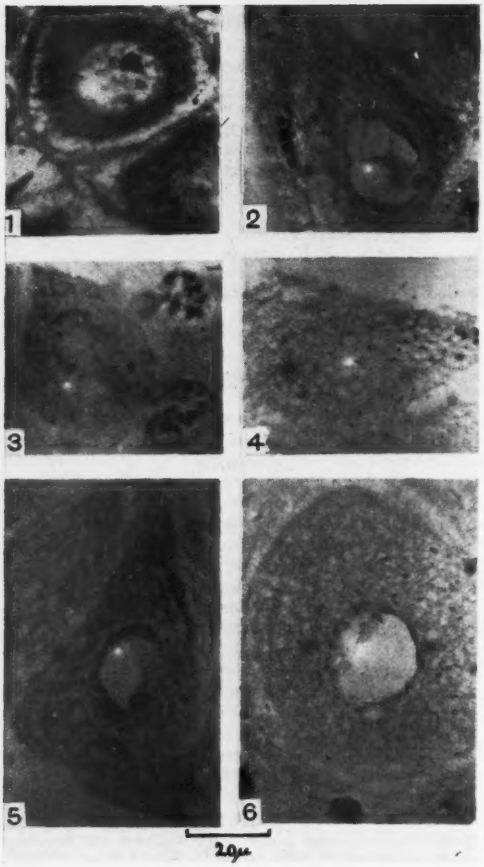
Treatment with insecticides was carried out as follows[2,3]. The insects were placed in a convenient glass container in which they were dusted (with a hand duster) or sprayed (with a small sprayer) and then left for 3-5 minutes, after which they were transferred to clean cages with normal conditions of moisture, temperature and food. Locusts treated with BHC (2·4 per cent), DDT (10 per cent) and pyrethrum (10 per cent) survived for about 16, 28 and 72 hours respectively. These concentrations were obtained by adding kerosine to the insecticide extract in the liquid form, or mixing the powdered form with calcium phosphate. The sodium arsenate powder (spread evenly and in small amounts on the foliage) allowed locusts to live for 15–24 hours.

In BHC-treated locusts the Nissl bodies of small neurones tend to accumulate into small groups distributed throughout the cytoplasm (Fig. 2). In larger neurones, the Nissl bodies decrease in number and migrate towards the outer region. (Compare Fig. 1 with Figs. 3 and 4.) They showed also a considerable accumulation in the region of the axon-hillock. In the largest neurones, the Nissl bodies are greatly reduced in number (Fig. 5).

The effect of DDT on the Nissl bodies is similar to that of BHC. In pyrethrum-treated insects the changes were less obvious: the nissl bodies showed less tendency to accumulate, and their size was slightly reduced.

In locusts poisoned with sodium arsenate, the Nissl bodies are greatly reduced in number (Fig. 6). In a few cells no trace of Nissl bodies could be seen.

We do not know why the Nissl bodies migrate, under the effect of insecticides, to the cortical part of the cytoplasm, but Young[3], working on the effect of normal sea-water and anærobic conditions on molluscan neurones, concluded that it was the lack of



Figs. 1–6.

Figs. 1–6. Photomicrographs showing the effect of insecticides on Nissl bodies of locust (all taken from the fourth nymphal instars). Materials fixed in Carnoy's fluid and stained in Borret's methylene blue. Fig. 1. Normal condition. Fig. 2. BHC-treated specimen showing the reduction in number of Nissl bodies and their tendency to accumulate. Figs. 3–4. BHC-treated specimens showing the reduced number of Nissl bodies and their migration towards the cell periphery. Fig. 5. Large neurone from BHC-treated nymph showing that Nissl bodies are greatly reduced in number. Fig. 6. Nymph treated with sodium arsenate in which very few Nissl bodies are found in the cytoplasm.

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oxygen which brought about the migration of the Nissl bodies along the axon of the cell after its death. Other pathological effects were reported by Young following axon sectioning. He noted that the Nissl substance began to disappear from the central part of the cell, and this continued until only a few granules, together with a few separate masses at the peripheral region of the cytoplasm, were left. Young noticed that the Nissl's bodies were reformed after fifteen days.

In the nerve cells of normal locusts the neurofibrillæ appear as threads surrounding the nucleus and passing into the axon[1]. The insecticides used exhibit no effect on the morphology or topography of the neurofibrils.

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PATHOLOGY

Tumourigenesis in Ovaries of Mice Transplanted to the Liver, Kidney and Adjacent Tissues

Ovarian tumours, though rare in normal mice, occur with high frequency under a variety of experimental conditions: low doses of total body X-radiation[1], transplantation to the spleen[2], application of 9:10-dimethyl-1:2-benzanthracene to nearby skin[3] return to normal site after a short sojourn in the spleen[4], in mice hereditarily deficient with respect to reproductive function[5], and in ovaries transplanted to the testes of intact mice[6].

Study of the morphological sequences in tumourigenesis in ovaries of mice in the intrasplenic position[7] and following low doses of total body X-radiation[8] has shown precocious loss of ovarian follicles to be a conspicuous common feature. Drastic reduction of follicles has also been reported in ovaries of mice subjected to benzanthracene[3] and in those genetically modified[5]. It is possible to refer the initiation of tumourigenesis in these ovaries to the local cellular imbalance. After reduction of the primary targets (granulosa cells) for gonadotropic hormone, latent growth potential is released in the interstitial cells. The tumour originates in an ovary that exists in an adult hormonal environment but is prematurely aged in so far as its content of follicles is concerned. Induced ovarian tumours in mice have been explained in terms of increased and prolonged gonadotropic stimulation[9].

In order to explore more fully the relationship between disruption of cellular organization and tumour formation in the ovary of the mouse, auto-transplantations were made to the liver and kidney. These were made to render unlikely any modification of the hormonal balance in the animal and, also, to produce loss of the germinal epithelium in order to speed reduction in number of follicles and obviate confusion concerning the source of the tumour cells. The formation of intrahepatic and intrarenal ovarian tumours in the rat has been reported[10].

Ovaries of recently born mice of the inbred strain *MAf/Sp* (a milk-agent-free strain of Marsh albino) were removed under cold anæsthesia, and one of each pair was thrust into either the liver or the left kidney. Recoveries were made at intervals of 4–6 weeks for 18 months; some ovaries were found in adipose tissue and in the body wall near the liver or kidney. The report is based on serial sections of 119 ovaries.

Although encapsulation did not occur regularly at any of these sites, as it does in the spleen, the germinal epithelium was absent. Reduction in number of follicles was slower in ovaries resident in the liver, kidney, and adjacent tissues than in the spleen; this may be referred to the degree of vascularization. After the time of appearance of the first areas of disorganized growth during the 20th week after transplantation, 56 per cent of the ovaries recovered contained tumours. During the last 6 months of the experiment tumours were found in 65 per cent of the ovaries. In no instance did disorganized growth begin until the follicles were conspicuously reduced in number; ovaries characterized by marked loss of follicles always contained tumour areas. Luteinization of interstitial cells and granulosa cells of regressing follicles was common from an early period as in intrasplenic and X-irradiated ovaries. The pattern of tumour formation by the interstitial (stromal) cells of

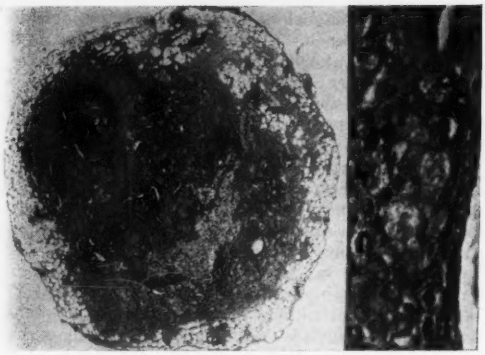

Fig. 1. Tumour in ovary of mouse after 77 weeks in subcutaneous site. Left, entire section ; right, cellular detail.

the ovaries reported here was much like that of the intrasplenic ovary (Fig. 1). It may be noted that control ovaries from *Maf/Sp* mice 16 months old contain normal follicles and corpora lutea and none of the atypical structures found in the transplanted ovaries.

A portion of uterine horn from each mouse was examined to determine the hormonal output of the transplanted ovaries. Although there was variation in the level of response among mice of a given lot, especially in the earlier stages, the horns were œstrogen stimulated[11]. The matrix of the stroma was abundant, mitotic figures occurred in the glandular and surface epithelium, and secretion was present in the glands. As tumourigenesis began, cystic hyperplasia was common and leucocytes were present in the stroma. Metaplasia was observed in a few horns.

The observations support the view[8] that local factors play an important part in tumourigenesis in the ovary of the mouse. The primary lesion is found to be a profound disturbance of cellular balance by loss of the dominant structures of the organ. Under such conditions, the growth potential of cells ordinarily relatively quiescent is released in response to what can be presumed to be the normal flow of hypophyseal gonadotropins. The importance of cellular balance in biological controls has been discussed by Little[12].

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AGRICULTURE

Routine Methods for Determining Quality in Merino Wool

USUALLY two distinct definitions are given of the term 'quality'[1,2]. First, there is the technical definition which is usually employed by the wool textile trade and which refers to the diameter of wool fibres. Secondly, there is the relative or primary definition which expresses an ideal so that a wool is said to be of good quality if it possesses to a marked extent the desirable features of its type. The term 'quality', as employed in this note, refers to the second definition and has no connexion with fibre diameter.

According to South African woolmen quality implies softness and kindness of handle and a well-defined, even crimp. Similarly wool textile experts with long industrial experience are able to predict the behaviour of a wool during processing from its appearance and feel. These subtle properties associated with wool quality have so far proved to be incapable of exact measurement by routine methods.

Samples of 50 Merino wools were submitted to four wool experts for the appraisal of quality in three degrees, namely good, fair and poor. From the 50 samples only 12 wools, in which there was good agreement between the experts in the appraisal of quality, were selected for this study. Only root portions of these wool samples were used for the following determinations : plasticity[3], total sulphur[4], tyrosine[5,6], solubility of wool in alkali[7] and urea-bisulphite[8] solutions. The averages of these determinations together with their standard errors are given in Table 1.

TABLE 1

Quality	No. of samples	Plasticity ($K \times 10^{-5}$)	Sulphur per cent	Tyrosine mgm. per gm.	Alkali solubility per cent	Urea-bisulphite solubility per cent
Good	4	89·7±8·4	3·43±0·07	70·1±0·8	11·4±0·3	50·6±1·7
Fair	4	74·3±8·4	3·57±0·06	62·3±0·9	9·0±0·4	45·6±4·2
Poor	4	60·0±4·8	3·69±0·05	58·7±1·4	7·2±1·0	44·2±2·8

The results indicate that all these methods may be used to characterize wool quality. Of special interest are the solubilities of wool in alkali and urea-bisulphite solutions as these determinations are of a routine nature. The relationship between these solubilities and wool quality has also been established in two other sets of wool samples as will be reported elsewhere.

Recently Dusenbury[9] has shown that the urea-bisulphite solubility measurement is a useful way of characterizing the cortical structures. The lowest solubility is exhibited by the paracortical fibre (for example human hair), the highest solubility by the orthocortical fibre (for example kid mohair) and intermediate solubilities are exhibited by the ortho-para fibres. These results for the solubility in urea-bisulphite, therefore, show that good quality wool contains a greater proportion of ortho-cortex than the inferior qualities.

The solubility of wool in alkali and urea-bisulphite solutions is also used to determine damage in wools[10]. In order to establish the effect of photochemical decomposition on the relationship between quality and solubility in alkali, wool samples were taken from 173 sheep of different qualities and the solubility

determined on whole wool staples. It should be stressed that these wools were grown on flock sheep which grazed under very exposed conditions where photochemical decomposition would be very severe. The average results and their standard errors are given in Table 2.

Table 2

Quality	No. of samples	Alkali solubility per cent
Good	46	13·0 ± 0·2
Fair	84	11·3 ± 0·2
Poor	43	10·7 ± 0·3

These results clearly illustrate that the relationship between quality and solubility in alkali is still valid even when whole wool staples are used for the test, although the results are not so sensitive as those reported in Table 1. This finding should be of considerable interest to the blender and topmaker. It is a well-known fact to the top trade that it is possible to produce different types of tops at a given fibre diameter (quality number), each with its own characteristics suitable for particular branches of the trade. With an alkali solubility test it should now be possible to characterize a blend or top at a given quality number. A top with a low solubility in alkali is not expected to exhibit the same good spinning properties as a top with a higher solubility in alkali[11]. On the other hand a top with a low alkali solubility should be more resilient, rigid and harsh to handle. Unpublished results of this laboratory show that the good quality wools felt much better than the inferior qualities. A blend with a too high alkali solubility should, therefore, also be unsatisfactory from a spinner's point of view as such wools would tend to felt during scouring with subsequent difficulties during carding and combing.

Routine determinations of the solubility of wools in alkali and urea-bisulphite solutions by producer and manufacturer, in association with the usual dimensional characteristics of the fibres, should permit of more aspects of wool quality being brought under control. This new approach to wool quality should provide a more precise link between producer and manufacturer and thus remove a major disability.

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PREHISTORY

Dating of Australian Prehistory

Australia, to prehistorians, is the least known continent. At most, the three million square miles available for aboriginal nomadism are represented by four or five excavations possessing chronological or cultural significance. There are several carbon-14 age estimations for aboriginal sites; but with one exception, they date unstratified surface hearths, or deposits where artefacts are either so generalized in type that they preclude satisfactory cultural designation or, as at Keilor, they are completely absent.

The exception is the Devon Downs rock shelter, in the Lower Murray valley of South Australia, excavated to a depth of 18 ft. This was in 1929. Because the excavators retained bulk samples of soil from each stratum, 25 years later it provided sufficient mussel shells from the layer 9 sample to enable the radiocarbon age estimation of 4250 ± 180 years. This dated horizon contained *pirris*, delicately retouched, symmetrical, uniface points, known from surface collections over half the continent; there is no record of their use by aborigines since European settlement.

For two months during 1956 and 1958 a University of Melbourne expedition excavated another shelter, at Fromm's Landing on the Murray, ten miles downstream from Devon Downs. In the largest controlled excavation so far attempted in Australia, a section 30 ft. long, 11 ft. wide and 16 ft. deep resulted. Twelve definite stratigraphic horizons were determined (numbered 0–11), all of which contained artefacts. The top five (0–4) were characterized by crudely made artefacts, which contrasted with the fine craftsmanship of lower levels; the same levels produced only one of the 41 bone implements recovered. Carbon-14 age determinations were made on two samples submitted to Dr. T. A. Rafter, at Lower Hutt, New Zealand. An age of 3240 ± 80 years was obtained from pieces of charcoal collected in level 4, six feet from the surface (*R*456/2).

Levels 5–10 were rich in cultural material. Four fusiform bones, probably intended as fish gorges, were found in levels 5, 6 and 7. Similar points were uncovered in the middle horizons at Devon Downs and termed *muduks*. Levels 6, 8 and 10 produced a total of five *pirri* points, while eight classic *microliths*, chiefly crescents, occurred in levels 8–10. Indisputable geometric *microliths* have never before been excavated in a stratified context in association with other implement types. It is evident, that at Fromm's Landing, *pirris* and *microliths* are of the same age. The occupation of level 10, 12 ft. from the surface and containing both types of artefact, has been dated to 4850 ± 100 B.P. (*R*456/1). The sample consisted of mussel shells.

This association of *pirris* and *microliths* is an important clue for the Australian prehistorian. It is significant that variants of both types appear in undated contexts in Indonesia[2]. It is also important that the Devon Downs date for the age of the *pirri* is confirmed by the new evidence. (The Devon Downs age estimation is for an horizon somewhat above the first appearance of *pirris* at that site). The next requirement is the excavation of sites in other areas, and the carbon-14 dating within stratified contexts, of these and other characteristic Australian implement types.

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